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BULLETIN

OF THE

TORREY BOTANICAL CLUB

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Errata

Page 57, line 4, for "concentration" read "dilution."

Page 57, line 27, for "3 per cent." read ".5 per cent."

Page 57, line 29, for "1.5 per cent." read "1 per cent."

Page 65, the percentages in the first section of Table I should be reversed: for "3%" read "½%," for "1½%" read "1%," for "1%" read "1½%" and for "½%" read "3%."

Page 133, last footnote, for "Febuary" read "February."

Page 137, line 5, for "hydrids" read "hybrids."

Page 223, line 15, for *A. Battandieri* read *R. Battandieri.*

Page 261, line 19, for *S. inconspicua* read *G. inconspicua.*

Page 331, line 24, for "upper leaves" read "upper surface."

Page 340, line 26, for "babit" read "habit."

Page 347, line 14, for *Gymnopterus* read *Gymnopteris.*

Page 350, line 1; page 353, line 25; page 358, line 5, for "Fee" read "Fée."

Page 352, line 26, for CHEILANTHUS read CHEILANTHES.

Page 374, line 7, for MONACHNE PUNCTATA read **Monachne punctata.**

Page 377, line 34, for **Isachne angustifolium** read **Isachne angustifolia.**

Page 378, line 35, for TRICHACHNE INSULARE read TRICHACHNE INSULARIS.

Page 453, line 6, for "presence" read "precedence."

Page 503, lines 25 and 34, for "Nemeč" read "Němec."

The Index to Recent Literature has contained a number of minor inaccuracies. The most important which have been noted are the following:

Claassen, E. Twice incorrectly spelled **Claasen** (page 184).

Kearney, T. H. The Protective Function of Raphides. The pagination should be 244 instead of 224 (page 567).

Norton, J. B. S. *Sclerotinia fructigena.* The date should be 1902 instead of 1892 (page 73).

Smith, J. D. Enumeratio, etc. The date of part 5 should be 1899 instead of 1903 (page 462).

Van Tieghem, P. Wrongly spelled **Van Teighem** in one instance (page 570).

VOL. 30 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY, 1903

Problems in the Study of Plant Rusts*

BY J. C. ARTHUR

The inception of the Botanical Society of America was the crystallization of a desire on the part of a number of zealous botanists to encourage research and to promote the general welfare of the science in America by concerted action. The result has been conspicuously successful. Beside providing an atmosphere of tolerance, expectancy and discriminating appreciation for the presentation of papers, by no means a small honorarium in the intellectual remuneration of the earnest investigator, a fund of money has been provided in accordance with the original intent of the founders, with which to assist and encourage research. The first distribution from this fund is made at the present meeting. It is a matter of congratulation that the wisdom shown in devising the plan for its creation and the business sagacity brought to bear in its management have enabled the society to offer a sum not only large in consideration of the age and membership of the organization, but equally noteworthy in comparison with any similar fund provided by American societies of whatever age and size. Without question the society is established squarely upon the doctrine of research, and the other benefits emanating from a body of this kind, which are by no means few, inconspicuous, or undeserving of consideration, are as the glory of a noble tree with its foliage, flowers and fruit, useful and luxuriant in proportion to the quantity and quality of its nutriment.

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* Delivered at Washington, D. C., December 31, 1902, as an address by the Past President of the Botanical Society of America.

[Hereafter the exact date of publication of each issue of the BULLETIN will appear in the succeeding number.]

In the selection of a subject for the present address it has seemed fitting that the central thought of the society should find a measure of expression, and therefore I have brought together some of the suggestions, entanglements and problems that have arisen during a series of investigations into the life histories of a number of the plant rusts. I do this with the more alacrity as it enables me to bring before you, and possibly to introduce to some of you for the first time, a remarkable class of plants of great scientific and economic importance.

The plant rusts, or Uredineae, are microscopic fungi, strictly parasitic in their nature, inhabiting all classes of flowering plants and ferns. The mycelial body of the fungus consists of colorless hyphae which ramify through the tissues of a larger or smaller part of the host. Sometimes they permeate every part of the plant above ground, but more usually are confined to certain areas, often very small and circumscribed. It is at all times difficult to distinguish this vegetative part of the fungus from the cellular structure of the host, unless special differentiating methods are employed.

On the other hand the reproductive parts are comparatively prominent, being yellow, red, brown, black or some characteristic tint, and with few exceptions are formed at or near the surface of the host, and of sufficient size to permit recognition under a hand lens or often by the unaided eye. These fruiting bodies are generally dehiscent, exposing the spores as a waxy or powdery layer. When produced abundantly, and of an orange or brownish color, the supporting plants have the appearance of being dusted with iron rust, which has suggested the now common name of plant rusts. The most generally recognized examples are the rusts of wheat, oats and other grains, which cause a loss to the people of this country of many millions of dollars annually, often equalling that caused by the Hessian fly, chinch bug and all other insect and fungous enemies combined.

The fruiting parts and especially the spores are the only portion of the rust fungus seen or recognized by the general observer, the botanical collector, or the average student. Not only are the spores readily seen, but as a rule they are easily removed and examined under the microscope, needing no preparation except moistening with a drop of water. Moreover, dried specimens keep indefinitely in all their perfection of form and intimate structure, and also as a rule of color. Hence it has come about that the description of species and the general classification has been founded almost exclusively upon the spore forms. This was a necessity at first; but it is a crude and artificial method. It has led to no clearer understanding of the real relationships of the species than did the Linnaean system for flowering plants, with its countings of stamens and pistils. Yet this comparison does scant justice to the intricacies of the subject, and the difficulties under which the systematic uredinologist has labored.

The student of phanerogamic plants, even back to the days of Linnaeus, has been well aware that few of the plants which come under his observation have more than one kind of flowers. The flower contains the pistils and stamens, from the interaction of which arises the fruit. Sometimes, to be sure, the pistils and stamens are in separate flowers on different parts of the plant, or even on different plants, as in the willows and poplars. But with rare exceptions, so rare as to have no appreciable effect upon the development of the subject, no material difficulty has been experienced in detecting the essential organs of reproduction, and no question has arisen regarding their association with the fruit which follows their appearance.

In order to come to an appreciation of the conditions existing among the rusts, and some of the difficulties besetting systematists in trying to unravel relationships, let us suppose some changes in the phanerogamic world. Let us begin by supposing flowers to be wholly suppressed, so completely in fact that the fruit would appear to arise from swollen buds, as figs do in fact, only in the case we are supposing the flowers are so totally suppressed that even the microscope reveals no trace of them. Now in this imaginary world each kind of tree, shrub and herb may bear not only one form of fruit, but two, three, four or even five forms as different as peaches, acorns, chestnuts, beans and currants. Two or more of these may occur at the same time in any variety of combination. Often delicate, peach-like fruits will be produced in a succession of crops throughout the summer, then in the fall a crop of acorn-like fruits that are not injured by hanging on the plants all winter. But more curious than this, the seeds from one kind of fruit rarely produce a plant that will bear the same kind of fruit again. If the acorn-like seeds are planted, the plants that are grown may bear acorns, but are rather more likely to bear fruits enclosed in sacs like chestnuts. To some extent this alternation of forms appears to be haphazard, at least dependent upon conditions not understood, but to a large extent it seems to be a question of the species. If acorn-like fruits from one species of plant are sown they give rise to plants bearing currants, soon followed on the same plants by chestnuts. When the chestnuts from this species are sown the resulting plants bear peaches, followed on the same individual plants by acorns. But there is no predicting what combinations will occur in any one species. When different kinds of fruits are found on the same individual they are known, of course, to belong to the same species, but when on separate plants their connection can only be told by actual planting. To further complicate matters one kind of fruit, the currant we will suppose, has seeds that cannot be made to develop into a plant, although they will germinate; and their purpose in the economy of the plant cannot be conjectured.

Let us fancy now that all plants of this imaginary world are exceedingly small, even the largest trees not being half the size of a pin, while the smaller plants are mere specks, in fact microscopic. How long do you think it would take botanists, with a flora of this sort, to become acquainted with the different varieties of each kind of fruit, and to connect the several forms into the cycle of true species?

In this fanciful sketch I have tried to portray some of the simplest conditions that exist among the rusts, using the fruits of currants, chestnuts, peaches, acorns and beans to represent respectively spermogonia, aecidia, uredo, teleutospores, and amphispores, in order to show how complicated they are in comparison to the conditions that exist among flowering plants. If I have succeeded in making my analogy clear, it can be readily understood that the earlier botanists gave names to each spore-form, believing it to represent the whole species. Thus *Uredo segetum* was the name of the red rust of wheat, *Puccinia graminis* the black rust of wheat, *Aecidium Berberidis* the cluster-cup rust of barberry bushes; and they certainly appear distinct enough to belong to different genera, although now we know them to be forms of one species. The ablest writers, down to the days of DeBary at the middle of the nineteenth century, described all species of Uredineae under the form-genera, each species thus being divided among as many genera as it had kinds of spores. Even to the present time the practice continues as a matter of convenience. Yet as early as 1810 Friedrich von Strauss entered a protest against placing such obviously connected forms as the *Uredo* and *Puccinia* of wheat under two genera, but in his attempt to readjust the forms under a suitable nomenclature he illustrated what deplorable systematic work can be done with a good logical basis but a lack of accurate observation. While he believed that many *Uredo* and *Pucciniae* were genetically connected, he made a vigorous objection against the association of certain *Aecidia* with these forms. In a communication to the Wetterau Society he says: "The assumption that these fungi [*i. e.*, *Uredo* and *Puccinia*], at least *Uredo segetum*, originate from the scattered red dust of *Aecidium Berberidis*, nature had already refuted before experience. Numerous examples are known to me, where the digging out of barberry hedges did no more good than did previously the destruction of crows in the American colonies." I do not know what action was taken in these early times against crows in our country, but I know that the colony of Massachusetts in the reign of George II. passed a law entitled "An Act to prevent Damage to English Grain arising from Barberry Bushes," with very stringent provisions for its enforcement, which law remained on the statute books twenty-five years.

Von Strauss was certainly in error in his conclusion that digging out barberry bushes did no good, as he might have learned, had he examined Marshall's "Rural Economy of Norfolk," a most readable book that had at the time passed through more than one edition; and, moreover, he was fundamentally wrong in assuming that there could be no causal connection between such apparently diverse fungi as the cluster-cups of the barberry and the yellow rust of the wheat, as was proven by DeBary experimentally a half-century later.

It is to DeBary that we are indebted for the first clear insight into the life-cycle of the rusts. He brought to their study more rigid methods of observation than his predecessors, and above all he first used culture methods, which have since become the crucial test of all uredineous species, and the key to the complex cycle of their development. It was in January, 1865, that Professor Anton DeBary, of Freiburg, laid before the Berlin Academy a paper dealing especially with the development of *Puccinia graminis* and its connection with *Aecidium Berberidis.* It was the opening of a new era in the study of plant rusts. Botanists had already become somewhat familiar with the succession of aecidial, uredo and teleutosporic forms among the rusts, but DeBary took up the most difficult, complex, and enigmatical of all the rust species, which at the present day even is very far from being fully understood; I refer to the black rust of grains, especially of wheat, which economically as well as scientifically is no mean problem, as it causes a loss in this country alone of some millions of dollars a year. He studied the germination of the spores from the wheat plant, and acting upon a suggestion derived from the practical farmer sowed the teleutospores upon barberry leaves, and raised cluster-cups. For more than a century the close observer of farm crops had strenuously maintained that barberry bushes near wheat fields increased the amount of grain rust, and the botanist had scornfully laughed and asserted that no known fact in nature warranted such an absurd idea; but DeBary vindicated the farmer.

The following year DeBary announced that oat rust bears its aecidia upon buckthorn leaves, and that rye rust has its aecidia upon alkanet, an Old World weed. The same year Oersted, a Danish botanist, published the results obtained by the DeBary culture method, showing that the rust of cedar trees is connected with the cluster-cups on leaves of pear trees.

Thus was the new doctrine of heteroecism established: the existence at different periods of growth of unlike forms upon totally unlike host plants. Its acceptance, however, was slow, and the culturists were few. During the seventies and eighties the attitude of most botanists was far from cordial. A few accepted the doctrine, but it exerted little influence upon the course of development of the general subject of uredinology.

It was, however, during this period that cultures were made by

Farlow, Thaxter and Halsted upon the connection between cedar rusts and the aecidia on Pomaceae, from which most of the present knowledge of American *Gymnosporangia* has been derived, a genus of rusts especially North American in the number and diversity of its species. And it was during this period that Plowright in England cultivated the rusts and ably presented the claims of heteroecism. In Germany Rostrup, Schröter, and Winter made cultures, and the last two, more than all others of this period, permitted the doctrine to influence their systematic treatment of the order. Each began, and carried well forward, the fungous flora of a large region: the Kryptogamen Flora von Schlesien and the Kryptogamen Flora von Deutschland, Oesterreich und der Schweiz, in which the Uredineae were elaborated in a manner yet unapproached. These two works, with Burrill's Parasitic Fungi of Illinois, Part I., which was issued during the same period, and inspired by Winter's work, are the only systematic handbooks of the order, founded upon a critical study of specimens, that are available to the American collector even to this day, although they were published from fifteen to twenty years ago. Since that time the number of known species has more than doubled, and the volume of information about them has quadrupled.

We may pause a moment here to recall what Sachs, writing near the beginning of the era of culture studies, said in his History of Botany about parasitic fungi, of which the Uredineae are the chief representatives. He characterized them as "the most attractive objects in the whole field of mycology," and said that "here were difficulties in abundance, here were the darkest enigmas with which botany has ever had to deal." Among the difficulties he had in mind were "to discover what properly belonged to one cycle of development" and to find where in this cyle the sexual fusion occurs.

Regarding sexuality of the rusts there is still dense ignorance, but regarding the exact cycle of development great advances have been made. DeBary supplied the key to this garden of knowledge, and during two or three decades some twenty botanists essayed the tedious but interesting task of growing one or more species of Uredineae and tracing the succession of forms through a life-cycle, some sixty or seventy heteroecious species being thus investigated. During the last decade of this era, however, more botanists have worked at solving these riddles, and some of them have made the work continuous from season to season, taking great pains to explore suggestive by-paths. The results have not been confined to a knowledge of life-cycles of individual species, but have brought to view some unexpected facts of far-reaching significance, regarding the limits of species and their biological behavior. Doubtless many who listen to me to-day also heard the vice-presidential address of Professor Farlow before the botanical section of the American Association for the Advancement of Science in 1898, in which he traced with great clearness and with many side-lights, the modification and broadening of our conception of species through recent cultural work on rusts. It would be superfluous to retrace the ground, even were I capable of equalling the admirable presentation, but some phases of the subject, which have since become prominent, may well be mentioned here.

One of the most eminent investigators in this line of research, to whom science and also the world at large owes much for his work on grain rusts, is Dr. Eriksson, of Stockholm. The great unfolding and clarification of a subject of such vast economic importance justly merited the gold medal and other honors, which have been bestowed. That what had previously been rated three species of rusts, *Puccinia graminis*, *P. rubigo-vera* and *P. coronata*, have been found under the search-light to be seven or eight species or possibly ten or twelve, with numerous specialized forms or so-called biological species, is some indication of the thoroughness and extent of the labor. Practically it has been of the greatest value to know that the rust of grains belonging apparently to one species cannot usually be spread by the uredospores from rye to wheat, rye to oats, oats to barley, or in general from one kind of grain to another. But mapping out the possible distribution of each species of grain rust still requires a vast amount of work, as not only the cultivated grains are involved, but many species of wild grasses.

In passing, attention may be called to a remarkable and seemingly anomalous property belonging to the principal grain rusts, that of attacking hosts standing in two or more tribes of the Gramineae. Of the hundreds of other species of rusts inhabiting grasses it is probably safe to assert that not one spreads to hosts outside of a single tribe. No full explanation of this is yet forthcoming, but when found it is likely to throw a flood of light upon the true nature of parasitism.

We return from this digression to note that Eriksson has vigorously attacked the difficult problem how the rust is carried through the winter and again becomes a menace to the farmer in northern regions, where the mycelium is not perennial and where barberry and alkanet or other suitable host plants are wanting on which the cycle of development can be completed. In trying to account for the facts he has elaborated and widely published a micoplasma theory: the symbiotic and intimate association of the protoplasm of the host and its parasite, unseparated by cell walls. This theory has not been accepted by most botanists, and since the recent publication of Marshall Ward's researches upon the rusts of the genus *Bromus*, appears to have no authentic or even probable facts upon which to rest. The studies of Carleton upon the American *Euphorbia* rust, in which it was found that the mycelial fungus may be carried over the winter in the seeds, may throw some light upon Eriksson's anomalous results, without invoking a micoplasma theory. We may, indeed, believe that to solve the practical problems of the mode of propagation and the power of infection of the several grain rusts requires all the astuteness and skillful experimentation that can be brought to bear; and the repeated failures of the ablest investigators only emphasize the difficulties.

The expansion of knowledge through DeBary cultural methods cannot be better illustrated than by citing the results attained by Dr. Klebahn of Hamburg with the willow and poplar rusts. This investigator stands foremost among those who have used each season's work as a basis for shaping the work of the following season, and who *pari passu* with cultural results have studied morphological characteristics, combining the two classes of data into taxonomic expression. Most systematists have contented themselves with listing the willow rusts under *Melampsora salicina* and the poplar rusts under *Melampsora populina*, or equivalent names. This was the disposition of them made by Winter and Burrill. Some have essayed segregation, but with an unsteady hand. Thümen in 1879 described seven species of willow rusts and

Schröter in 1887 recognized four willow rusts and three poplar rusts. The characters for these were drawn chiefly from the uredospores, although the latter author was guided somewhat by the limited cultures of Rostrup and Nielsen.

The matter presents a wholly different aspect when we turn to the conclusions reached by Klebahn. From an external knowledge of the species we are presented with an intimate knowledge, and from conjecture we pass to reasonable certainty. It is somewhat startling, nevertheless, to find that the original single willow rust has become fourteen, and the one poplar rust has become seven. One of the willow rusts, quite unsuspectedly, proves to be autoecious, having its aecidium on willow leaves along with the uredo and teleutostage; all the other species are heteroecious, with their aecidia on *Larix*, *Euonymus*, *Ribes*, *Orchis*, *Allium* and *Galanthus*. The poplar rusts are all heteroecious, with their aecidia on *Larix*, *Pinus*, *Allium*, *Mercurialis*, *Chelidonium* and *Corydalis*. Most of these species can be told from one another by morphological characters quite as readily and as certainly as can the species of *Viola*, *Crataegus* and *Antennaria* in the present congested condition of these genera; but some of them are difficult to distinguish in this way. For instance, the five species which occur on *Populus tremula* can scarcely be told apart unless the aecidial host is known.

As an incidental piece of information it may be stated in this connection that all the willow and poplar rusts investigated by Klebahn are European. Although similar rusts are common in this country, and often sufficiently abundant to be destructive to their hosts, yet none of them has so far been identified with European species; and, moreover, the most common forms may be assumed, with some degree of certainty, to be distinctly American.

But to return to the question regarding species that are morphologically similar, but ecologically dissimilar; it appears to be possible for all five of these *Melampsorae* on *Populus tremula* to grow side by side on the same individual leaf, in which case the uredospores would be practically indistinguishable by any direct morphological or cultural test, the teleutospores could only be told apart by ascertaining what species of host they could be made to infect, while the aecidia would be known by the particular host they inhabited. The aecidial hosts in this case are exceedingly diverse and represent about the whole gamut of the spermatophytes. A similar case is that of the American *Carex* rusts, having aecidia on the three large intergrading genera *Solidago*, *Aster* and *Erigeron*. Although they have not yet been studied thoroughly enough to speak with entire confidence, still it is evident that they have very slight morphological distinctions, and possibly have no constant differential characters except the association of the aecidial host.

The practical question that arises is in regard to the systematic treatment of such forms. Shall they be classed as species, subspecies, varieties or races? This is not so much a question of fact, as of convenience and intelligent interpretation. No one, nowadays, believes that species are circumscribed in any definite manner, but that usually they exhibit developmental mobility which is recognizable in all manner of intergradations and differentiations. What is wanted of systematic botany is a nomenclature that expresses in a fair way the relation that exists between forms as found in nature. It will at the best be an imperfect and unequal interpretation of the facts, but it surely ought to be employed with understandable uniformity.

Botanists, I believe, have not often gone to the extreme of some of their co-workers in allied sciences. From a communication in a recent number of Science it appears that "in ornithology, and especially in mammalogy, perfectly good species are often so similar in size and color that even the expert can not satisfactorily identify them from descriptions. * * * They present to the eye differences that are sufficiently impressive but which, owing to the imperfection of descriptive terms, can not be adequately expressed in keys or in diagnoses." If one may venture an opinion on matters outside of his own domain, forms which differ by such intangible characters as here indicated, so that they can not be expressed on paper, are not species in the generally accepted sense. They may be deserving of names, and be of great interest to the specialist, and may serve most important ends as basis for particular inquiries, but their rank is not that of true species in the general sense; at least, I think this may be safely asserted if plants are in question.

I need not speak of the validity of physiological species as adopted by students of bacteria and yeasts; they have their place. In fact, I do not deem it necessary to bring up for discussion the hackneyed subject of what constitutes a species. Even were I polemically disposed, it would be hazardous; but I have in mind only to call attention to the hyphenated nomenclature so effectively used by Klebahn, Fischer, and others, to indicate dichotomous parasitism. For instance, what has been considered *Melampsora populina* occurring upon *Populus nigra* is found to be separable by cultures into two forms, one having its aecidium on *Larix* and the other on *Allium;* these two forms are named by Klebahn *Melampsora Larici-populina* and *M. Allii-populina*, although they may not be morphologically distinguishable.

Such names are descriptive, and a great help in following the diversified results of cultures. Whatever their status in strictly systematic work, they would appear to have their use and be permissible for cultural studies. But when the conclusions of the culturists are transferred to systematic botany the provisional nomenclature must necessarily be subjected to the rigid laws of priority; moreover, questions regarding the propriety of accepting the cultural forms as species must also be settled to accord with general usage. In making such changes it is doubtful if the systematist could safely rank as species forms that have not a reasonable morphological distinctness in addition to their host connections. The morphologically distinguishable species, like *Melampsora populina*, may be separated into varieties showing selective parasitism, like the varieties *Larici-populina* and *Allii-populina*. If some such method is not adopted, we may well be appalled at the probable condition of systematic uredinology a few years hence.

At present there are only about a dozen culturists active. In North America alone a hundred species of grass and sedge rusts are known, which of course does not include all the heteroecious forms. Of these less than twenty have been traced to an aecidium, and none have had more than a preliminary investigation. In what proportion these hundred species are likely to exhibit selective parasitism can not of course be told, but it is likely to be large. What is the future collector to do, if when he turns to his manual he finds that on the host he has in hand there are recorded from two to a dozen species, none of which can be told except by a cultural test? Would it not be better that he should find one species recorded for his host, having from two to a dozen varieties separable by cultures? Moreover, would not this accord better with usage in other fields of plant life, and at the same time give a more just conception of relationship?

Difficulties in this line are not confined to the heteroecious rusts. The autoecious species are likely to prove quite as perplexing and intricate when studied with equal thoroughness. The American species of rust on *Euphorbia*, called *Uromyces Euphorbiae*, has been somewhat examined culturally, and four cultural species have been found respectively inhabiting *Euphorbia maculata*, *E. nutans*, *E. dentata* and *E. marginata*. Both aecidiospores and uredospores have been used for the cultures, and in no case has it been possible to transfer the rust of one of these hosts to another; morphological characters by which to distinguish them, however, have not been found. Fancy the systematic situation for the *Euphorbia* rusts, when the other hosts are examined, not only of the eastern United States for which Britton's Manual gives thirty-six species, but of the western regions, and especially of Mexico and other warm countries where Euphorbias attain a greater development, many being woody and even tree-like, and where rusts on them are especially abundant.

But I ought not to weary you with more of this perplexing topic. Let the culturists and the systematists fight out their battles. It is difficult to foresee whether the outcome will be the establishment of order or the release of pandoric confusion.

Probably no part of the many-sided subject of the rusts is superior in interest to the fact of their complete parasitism. They not only vegetate inside the host without destroying it, but even at the fruiting points the tissues are rarely killed. On the contrary they often exert a stimulating effect upon the cells of the host, so that the tissues remain green, especially about aecidia, when other parts of the organ are yellow and dying. Another phase of the stimulating effect is seen in hypertrophied development. So intimate is the association of parasite and host that as a rule the vigor of the parasite is directly proportional to the vigor of the host. Every culturist soon learns, that to have success in his work he must employ strong, rapidly growing plants. Even if he succeeds in infecting weak plants, the fungus will rarely come to a satisfactory fruitage. Usually all growth of the rust stops with the death of the host, although in a few cases, especially in the genus *Melampsora* and *Coleosporium*, the teleutosporic development continues for a time after the leaves of the host have fallen to the ground, as among the willow and poplar rusts. This physiological fact supports morphological facts, which place these genera among the lowest of the Uredineae in the scale of development, and ally them to saprophytic forms. Probably the primitive Uredineae were wholly saprophytic and largely unspecialized as to host, but as they gained in power to attack living tissues, they became more and more restricted in their dietary choice. When we remember what remarkable chemotactic sensitiveness the germinating spores of many fungi possess, saprophytes as well as parasites, it is not difficult to account for a high state of specialization in the selection of a living substratum within which to function and from which to draw food-supplies.

This specialization of the parasite must have begun and been carried on in large part along with the specialization of the host, and we should be prepared to find a parallelism in their association. The large and peculiar genus *Ravenelia* is all but confined to the leguminous families of flowering plants. The genus *Phragmidium* is largely parasitic on the Rosaceae. The species of *Gymnosporangium* are found only on certain coniferous hosts, and their aecidia on the Pomaceae. And so we might continue, showing that there is some association, not at present wholly explainable, between certain tribes and genera of rusts and certain families and tribes which serve them as hosts, and in many cases this association is very closely circumscribed.

The knowledge of this parallelism is an important help in keeping us at the present time from falling into the error, so common among the older systematic students of the rusts, of assuming that forms on widely related species of hosts, however similar in appearance these forms may be, might belong to one species, without securing rigid proof. Not until recent years would it have been considered strange to announce that a certain species of rust had been found upon Borraginaceae, Asclepiadaceae and Compositae. A common expression has been that the form was found "on various species of grasses and sedges." But such instances as these are not known at the present day. There is no species known that inhabits grasses *and* sedges. Moreover, it is rare that any species of rust will be capable of growing on all the genera of a large family, or even on all the species of a large genus, unless these be remarkably homogeneous.

Is it not apparent that the exact identity of the species of host on which a rust is found constitutes information for the proper study of its systematic relationship and often of its specific identity only second to the characters drawn from the fungus itself? No rust can be considered apart from its host; the parasitism is so closely wrapped up in the evolution of the species that to ignore it would be folly. Many collections of Uredineae are rendered nearly worthless for study because the collector neglected to determine the host, or to include material in the collection by which the student could determine it. So little importance has been attached by collectors to this part of their work that rarely are characteristic parts of the host included, so that the student may independently satisfy himself of the correctness of the determination, and so that in after years the determinations may be revised, if necessary. It is usually forgotten that the classification of phanerogamic plants has not yet become perfect, and every change in their nomenclature must be reflected in the nomenclature of the uredineous hosts. Evidences of the lack of appreciation of the importance of correct determination of the hosts of the Uredineae are shown in many ways; I may cite an instance coming to hand while preparing this address. In an exhaustive treatise on the flora of the island of St. Croix about fifteen hosts are mentioned for the few rusts that had been collected, and four of these are not listed in the phanerogamic part of the work. Again in that admirable flora of Alabama, issued some time ago, the life-work of Dr. Mohr, a number of uredineous hosts are mentioned not in any way referred to under the families of phanerogams where they should appear. Another source of annoyance and of misinformation is the not infrequent failure of uredinologists to recognize hosts under their synonymic aliases. It is very easy at the present time for a plant to go masquerading under several names. Of course, the well-informed ought not to be deceived by these disguises, and if they were sufficiently on the alert they probably would not be. Yet it is not rare to have new species of rusts described because the describer did not recognize the host under its latest name, as an old-time acquaintance. This failure of recognition also leads to a fictitious multiplication of hosts cited for a species of rust. Saccardo's "Sylloge Fungorum" contains many instances of this. I may, however, mention a specific instance taken from a later work, in which greater accuracy is expected, that of Sydow's "Monograph of the Uredineae." The second part of this work, just from the press, gives *Ferula dissoluta* and *Leptotaenia dissecta* as two hosts for a species of *Puccinia*, and yet both are names of the same plant. This is not a solitary instance. Such discrepancies ought not to occur, and largely would not if more importance were attached to the identity of the host.

There are many topics connected with this intricate and many-sided subject of the rusts that I should like to bring before you at this time, but to do so must prove wearisome, even to enthusiastic students of the family; and I fancy there are a few such in this audience. I will, therefore, content myself with a single additional topic, and even that must be treated briefly.

I wish to point out the profound influence that cytological studies are likely to exert upon the morphological, evolutionary and taxonomic conceptions of the rusts, when these are carried far enough to explain the significance of nuclear fusions in the different sorts of spores, and to indicate where in the life-cycle the sexual fusion occurs, or originally did occur. Much patient work has already been done by eminent investigators, Dangeard, Sappin-Trouffy, Raciborski, Poirault, Harper and others, and many facts have been brought to light, but we are more bewildered than edified by the results.

There seem to be a few things that we may accept as reasonably certain. One is that no close relationship exists between the Uredineae and the Ascomycetes, as advocated by DeBary, but that, on the other hand, the Uredineae and the Basidiomycetes have direct kinship. The nuclear fusions found in the teleutospore and in the basidium appear to be of similar nature, although probably without sexual significance.

The simple structure of the vegetative parts of the Uredineae should not mislead us into thinking that the family represents a reduced branch of the Basidiomycetes, for in all probability one family is as highly developed as the other, only one is along saprophytic lines of adaptation, and the other along parasitic. There are, in fact, some reasons for supposing that the Uredineae stand in the lead.

Of the various problems which cytological studies are expected to illuminate, none is more pressing than to discover the probable original function of the spermogonium. This body was at first held to be of the nature of the male sexual organ, hence the name, but all the studies and observations of recent times have done little to establish this view. Most students of the rusts ignore the structure entirely, or attach slight importance to it.

Without going into an argument, or even presenting opposing views, permit me to call attention to some significant facts regarding the spermogonium. These facts, it seems to me, tend to substantiate the assumption that we are dealing with the structure that originally functioned as the male reproductive body, but which long since in the developmental history, has ceased its functional activity, and become in all respects a disappearing organ. In the first place, in all cases where the life-cycle is known, the first body that is formed from the mycelium arising from teleutosporic conidia is the spermogonium. It begins the series of spore structures. In a full series the next structure is the aecidium, then comes the uredo and the amphispore if the latter occurs at all, both being asexual spores to meet requirements for rapid and certain distribution, and finally the teleutospore, having its characteristic mode of germination. The uredo and amphispores may be left out of this cycle, and often are, without disturbing the vigor and success of the organism. If the aecidium is omitted, however, the spore-form immediately associated with the spermogonia will be the uredo. These uredospores which arise along with spermogonia, however, differ in some physiological characteristics from those that arise later, having a greater disturbing influence upon the host, and are usually designated as primary uredo. It is significant in this connection that cytologically the aecidiospore and the uredospore are essentially alike. Going a step further, in what I consider reduction, and having both the aecidium and uredo omitted, we have the spermogonium appearing just in advance of the teleutospore. There is but one possible further reduction, and that is the suppression of the spermogonium, and we then have the whole cycle reduced to the simple formation of teleutospores.

To present the whole basis on which my argument rests, would take altogether too much time, and even to answer the queries and possible objections that will arise in the mind of every one who has some acquaintance with the subject, is equally out of question at the present, and I will instead give the conclusions at which I have arrived, and trust to some future opportunity for substantiating them.

I look upon the spermogonium as the beginning of the life-cycle, or more logically, the most important point in the cycle, in a fully developed rust organism. With it, and its associated spore-form, is always found the greatest exhibition of fungous vigor, showing some remnant of the original sexual power. The teleutospores I consider the close of the life-cycle, and the structure that is absolutely essential to the species. In the course of reduction, due to parasitism, the female sexual structures disappear first, then the male, and the final state is that of a purely sporophytic form.

If in this review of some of the problems confronting the uredinologist, I have more bewildered you than clarified the subject, you may be somewhat consoled by knowing that it is the frame of mind in which uredinologists themselves are usually plunged when they try to think out a connected and logical statement for these perplexing fungi. The subject at the present time is too much in shadow to present a concrete, recognizable picture.

Hepaticae of Puerto Rico

II. DREPANOLEJEUNEA

By Alexander W. Evans

(With Plates 1–6)

The close relationship which exists between *Drepanolejeunea* and *Leptolejeunea* has already been commented upon in the first paper of this series.* It may be added that the species of *Drepanolejeunea*, like those of *Leptolejeunea*, are almost exclusively tropical, a single exception being found in *D. hamatifolia* (Hook.) Schiffn., a species originally known from western Europe but since reported from Puerto Rico and also from southern Africa.† Many species of *Drepanolejeunea* grow on living leaves, but others prefer rotten wood or the bark of trees, and *D. hamatifolia* often occurs on rocks. Certain species creep through tufts of mosses or other hepatics from which it is often difficult to disentangle them. It is much more common in fact to find several closely related species growing together on a leaf or a piece of bark than to find a patch composed of a single species.

In the "Expositio Hepaticarum Portoricensium" of Hampe and Gottsche ‡ three species of *Lejeunea* are included which are now referred to *Drepanolejeunea*. These are *D. hamatifolia*, to which attention has already been called, *D. inchoata* (Meissn.) Schiffn. and *D. tenuis* (R. Bl. & Nees) Schiffn. They were collected about fifty years ago by Carl Schwanecke in the vicinity of Humacao at the eastern end of the island. Only one of these species, *D. inchoata*, has since been found in Puerto Rico and there is consequently some doubt regarding the determinations of the other two. *D. tenuis*, for example, was first described from Java and although it has been reported from French Guiana § and also, much more recently, from Costa Rica,|| Spruce questions its oc-

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* Bull. Torrey Club, **29**: 496. 1902.

† Pearson, Christiania Vidensk.-Selsk. Forh. 1886^3: 5.

‡ Linnaea, **25**: 337–358. 1852.

§ G. L. & N. Syn. Hep. 390. 1845.

|| Stephani, Bull. Soc. Roy. Bot. de Belgique, **31**: 179. 1892.

currence in America.* With regard to *D. hamatifolia* it should be stated that no American stations for the species have recently been cited with any degree of certainty and that the American specimens quoted in the Synopsis Hepaticarum † undoubtedly belong elsewhere. Schiffner ‡ reports, nevertheless, that specimens of a *Drepanolejeunea* identical with this species or at any rate very close to it occur in Schwanecke's collection mixed with *Harpalejeunea patentissima*, and it is possible that these were the plants determined by Hampe and Gottsche. A fourth species, *D. subulata*, has recently been described by Stephani, likewise from Schwanecke's collection. It appears probable that this species is based on the "*Lejeunia tenuis*" of Hampe and Gottsche's list, although this is not definitely stated by its author.

The collections of Puerto Rico Hepaticae made by A. A. Heller and by the writer include ten species of *Drepanolejeunea*, all found in the Luquillo Mountains. Of these ten species *D. inchoata* and *D. subulata* have already been recorded from the island, four of the other species, *D. Araucariae*, *D. bidens*, *D. crucianella* and *D. infundibulata*, are known from other parts of tropical America, while the remaining four are apparently undescribed. Of the two recorded species *D. inchoata* has a wide distribution in South America and the West Indies, while *D. subulata* is known from Puerto Rico only. It will be seen therefore that fifty per cent. of the species known with certainty from the island seem to be endemic, a ratio which will doubtless be reduced by careful exploration of the neighboring islands.

In all the Puerto Rico species of *Drepanolejeunea* the lobule is constructed on essentially the same plan as in *Leptolejeunea stenophylla* and *L. hamulata*. This type of lobule is characterized by a peculiar curved cell or tooth at the apex, which assists materially in forming the opening into the water-sac of the leaf. At the base of the tooth on the side toward the axis there is present a slight depression or notch in which a unicellular thin-walled and hyaline papilla is situated. The terminal cell curves outward, coming into contact with the postical surface of the lobe and sometimes extending as far as the end of the keel, which in many cases curves forward and meets it. The extreme development of this type of lobule is seen especially well in *D. cruciancella* (*pl. 4, f. 13*) but is also found in *D. bidens* and in other species. The lower edge of the lobule is here adnate in its outer part to the postical surface of the lobe, giving rise in this way to a short and rudimentary wing which is scarcely a cell broad and only one or two cells long. The adnate portion of the lobule is itself only two or three cells long and a single cell wide ; its terminal cell, although attached at its base to the lobe, projects at its apex as a distinct tooth which meets the curved tooth at the apex of the lobule. These two teeth, together with the sinus of the lobule, form a circular opening into the water-sac. We find among the Puerto Rico *Drepanolejeuneae* all gradations between this extreme development of the lobule and that seen for example in *D. subulata*, where the terminal cell is only slightly curved and does not reach the end of the keel. We must bear in mind, however, that the development of the lobule is very dependent upon external conditions and that we frequently find specimens in which the typical lobular characters of the species are not clearly indicated.

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* Hep. Amaz. et And. 192. 1884.

† P. 344. See also Stephani, Hedwigia, 29: 71. 1890.

‡ Engler's Bot. Jahrb. 23: 591. 1897.

Although ocelli are not usually found in *Drepanolejeunea*, no fewer than six of the Puerto Rico species exhibit them. They are never conspicuous and their number (in the vegetative leaves at least) never exceeds two. Even in species in which they are normally present, many of the leaves, especially those which are poorly developed, fail to show them. The ocelli in most cases are no larger than the neighboring cells and usually retain their angular form even when their contents become lifeless. They are distinguished by the granular or fatty bodies which they contain and do not usually become hyaline and empty as in many other Lejeuneae. Sometimes the addition of potash solution brings them out more clearly. With regard to the uses of these ocelli practically nothing is known, although it is probable that they sometimes take part in the formation of the water-sac as in *Leptolejeunea exocellata*. It is not at all likely, however, that they are ever the empty mother-cells of disc-shaped gemmae as in certain species of *Cololejeunea* and probably of other genera. *Drepanolejeunea* in fact seems never to develop gemmae of this type but reproduces itself vegetatively by means of leafy propagula which are similar to those of *Leptolejeunea*.

In the present paper only those species are described of which specimens from Puerto Rico have been personally examined, but a few critical notes are interpolated regarding *D. hamatifolia* and *D. tenuis*. The writer would express his thanks to Mr. Matthew B. Slater, of Molton, Yorkshire, who has kindly loaned him for study the various species of *Drepanolejeunea* described by Spruce, and also to Herr Stephani, of Leipzig, who has confirmed several determinations.

Drepanolejeunea biocellata sp. nov.

Yellowish- or brownish-green, growing in thin irregular patches; stems 0.04 mm. in diameter, closely adherent to substratum, irregularly pinnate, the branches widely spreading: leaves distant to slightly imbricated, the lobe suberect to obliquely spreading, more or less convex, often deflexed at the apex, ovate, distinctly narrowed toward the base, 0.35 mm. long, 0.2 mm. wide, attached by a short oblique line of insertion, straight or slightly falcate, margin entire or more or less denticulate from projecting cells, sometimes with an indistinct angular tooth near end of keel, antical margin arched, postical margin straight or nearly so, apex obtuse to acute, usually tipped with a single cell, rarely with two cells in a row; lobule ovate, 0.14 mm. long, 0.09 mm. wide, inflated throughout or plane at apex and along part of free margin, keel arched, roughened near end from projecting cells, free margin sometimes plane and appressed to lobe but usually involute to beyond apex then passing by a lunulate sinus to end of keel, apical tooth strongly curved; cells of lobe plane or slightly convex, averaging 15 μ at the margin and 18×15 μ in the median and basal regions, walls more or less thickened, trigones and intermediate thickenings sometimes distinct, sometimes confluent and indistinct; ocelli commonly two, one in lower half of lobe, the other (sometimes obsolete) at or near the base, a little larger than the surrounding cells, measuring $27 \times 18 \mu$: underleaves distant, basal portion rectangular or trapezoidal, 0.05 mm. long, 0.045 mm. wide at base, marginal cells six, scarcely bulging, divisions widely spreading, consisting of two or three cells in a single row, with a spread of 0.1 mm.: inflorescence dioicous: ♀ inflorescence on a short branch, innovating on one side with a short and simple innovation; bracts obliquely spreading, complicate, unequally bifid, the lobe ovate-lanceolate, 0.35 mm. long, 0.15 mm. wide, acute, margin entire or irregularly and vaguely crenulate, lobule oblong, 0.2 mm. long, 0.09 mm. wide, truncate to bluntly pointed, entire;

bracteole free or nearly so, oblong, 0.3 mm. long, 0.15 mm. wide, bifid about one half with subulate acute divisions, margin entire; perianth obovoid, projecting somewhat beyond bracts, 0.6 mm. long, 0.35 mm. wide, narrowed toward base, truncate above and with a short beak, terete in lower part, sharply five-keeled above, the antical keel lower than the others and sometimes obsolete, keels rounded above or projecting as short horizontal obtuse or acute horns, more or less roughened or dentate at their extremities from projecting cells: ♂ inflorescence terminal; bracts in several to many pairs, inflated, shortly bifid, the lobe obtuse and the lobule rounded, keel strongly arched, bordered in the outer part by a row of bulging hyaline cells, bracteoles limited to base of spike, rudimentary; antheridia in pairs: mature sporophyte unknown (*pl. 1, f. 1–9*).

On living leaves and on a log. El Yunque, *Evans* (23 *p.p.*, 89 *p.p.*).

The original specimens of this species from which the drawings were made were collected in 1900 on living leaves and show no signs of reproductive organs with the exception of propagula. They may be looked upon as the type of the species because in them the foliar characters are better developed than in the fertile material with perianths collected in 1902 on a log. In all of the specimens examined branches with rudimentary leaves are frequent, and many of these microphyllous branches, but by no means all of them, bear leafy propagula similar to those described for *Leptolejeunea stenophylla* and *L. hamulata*. The leaf-cells of *D. bioccllata* are very variable with respect to the local thickenings of their walls. In some cases the cells have fairly thin walls with small trigones, in other cases the walls show conspicuous trigones and intermediate thickenings, while in still other cases the thickenings are more or less confluent and give the walls the appearance of being irregularly thickened. It is sometimes possible to find these various conditions on a single plant.

DREPANOLEJEUNEA SUBULATA Steph.

?*Lejeunea tenuis* Hampe & Gottsche, Linnaea, **25**: 356. 1852. Not *Lejeunea tenuis* (R. Bl. & N.) Nees.

Drepanolejeunea subulata Steph. Hedwigia, **35**: 83. 1896.

Pale yellowish-green, growing in loose thin mats or creeping among other prostrate hepatics: stems 0.05 mm. in diameter, prostrate, sparingly and irregularly pinnate, the branches obliquely or widely spreading: leaves distant to subimbricated, the lobe erect and subparallel with the axis or slightly spreading, plane or somewhat convex, oblong-lanceolate, 0.4 mm. long, 0.15 mm. wide, narrowed toward the base and attached by a short, slightly oblique line of insertion, margin irregularly crenulate from projecting cells, antical margin slightly curved, apex acute to abruptly acuminate, tipped with a single cell or more commonly with two or three cells in a single row, postical margin curved at about the middle of the leaf, usually forming an obtuse angle with keel; lobule ovate, strongly inflated (except in apical region), 0.15 mm. long, 0.1 mm. wide, keel strongly arched, more or less crenulate at least in outer part from projecting cells, free margin usually involute as far as apex, almost straight when explanate, passing beyond apex by a rounded to obtuse sinus to end of keel, apex acute, tipped with a single slightly curved cell; cells of lobe somewhat convex, thin-walled but with large trigones projecting slightly into cell-cavities, intermediate thickenings rare, cells averaging 23 × 16 μ at the edge of the leaf and 23 μ in the middle; base of lobe showing a distinct group of four oblong cells, each about 30 μ long and 9 μ wide; ocelli none; cells of lobule with wavy outlines and no trigones, averaging 14 × 17 μ: underleaves distant, basal portion quadrate, scarcely narrowed at line of attachment, 0.05 mm. long, marginal cells six, not bulging, divisions erect-spreading, consisting usually of three cells in a row, rarely two cells wide at base, with a spread of 0.06 mm.: inflorescence dioicous: ♀ inflorescence borne on a short branch, innovating on one side with a simple and sterile innovation; bracts obliquely spreading, scarcely complicate, unequally bifid, the lobe ovate, acute to acuminate, 0.4 mm. long, 0.2 mm. wide, margin subentire to irregularly and sparsely dentate or spinulose, lobule ovate, 0.3 mm. long, 0.15 mm. wide, acuminate to blunt at the apex, margin as in lobes; bracteole free or slightly connate at the base, oblong to subrotund, 0.35 mm. long, 0.15 mm. wide at base, bifid one third to one half with acute to acuminate divisions and acute sinus, margin as in bracts but usually less toothed; perianth somewhat exserted, obovoid, 0.7 mm. long, 0.35 mm. wide, narrowed at the base, rounded to truncate at the apex and with a short beak, terete below, sharply five-keeled above, the keels rounded in the upper part and slightly roughened from projecting cells, not projecting as horns: ♂ inflorescence terminal; bracts in a few pairs, large, rotund-galeate, compressed, truncate above, and scarcely bifid, with a row of hyaline projecting cells along keel (*pl. 1, f. 10–19*).

On bark of trees, mixed with other hepatics; north slope of the Luquillo Mountains, *Heller* (4712 *p.p.*, 4737 *p.p.*); El Yunque, *Evans* (53 *p.p.*). First collected by *Schwanecke.*

Drepanolejeunea subulata is closely allied to *D. tenuis* and also to *Lejeunea* (*Drepano-Lej.*) *anoplantha* Spruce, a species first collected by its author in South America but afterwards found by Elliott on Dominica and by Britton and Cowell on St. Kitts. These three species agree in their general appearance and in the possession of a perianth without horns, a most unusual character for the genus. *L. anoplantha* resembles *D. subulata* further in the shape of its underleaves and in the presence of four elongated cells at the base of its leaf-lobes. It differs from the Puerto Rico species in its broader lobes, measuring nine to twelve cells across instead of seven to nine cells, in its smaller leaf-cells, averaging 17 μ in the middle of the lobe, in the more obscure thickenings of their walls, and in its blunter leaf-apices, each tipped usually with a single cell.

Through the kindness of Dr. G. Lindau, of Berlin, the writer has had the privilege of examining specimens of *D. tenuis* collected by Teysmann in Java and determined by Gottsche. In these specimens the leaves are abruptly dilated above the base and then gradually narrowed to the apex, which commonly ends in a single row of three or four cells. This brings the broadest part of the lobe above the middle rather than at the middle as in *D. subulata.* In the Javan species also the apex of the lobe frequently points outward although this condition is not unknown in *D. subulata.* Perhaps the most striking difference between the two species is found in the distinct teeth on the antical margin of the lobe in *D. tenuis.* These teeth are commonly three to five in number, each consisting of a single cell or of two or three superimposed cells. On slender branches the teeth are sometimes poorly developed and sometimes more strongly developed than on robust axes. The perichaetial bracts and bracteoles of *D. tenuis* finally are strongly spinose-dentate.

Drepanolejeunea crassiretis sp. nov.

Yellowish-green, varying to brownish, growing in thin patches: stems 0.05 mm. in diameter, prostrate, irregularly pinnate, the branches obliquely or widely spreading: leaves more or less imbricated, the lobe erect and subparallel with the axis or slightly spreading at the base with the apex turned forward, strongly convex, oblong-ovate to ovate-lanceolate, 0.3 mm. long, 0.17 mm. wide, somewhat narrowed toward the base and attached by a short slightly oblique line of insertion, margin subentire or indistinctly crenulate or denticulate from projecting cells, antical margin arched, postical margin more or less involute beyond keel, in explanate leaves forming a continuous line with keel, apex varying from rounded to acute, on slender leaves occasionally tipped with two superimposed cells; lobule strongly inflated throughout, ovate, 0.17 mm. long, 0.09 mm, wide, keel strongly arched, slightly roughened in outer part from projecting cells, free margin involute to beyond apex, then passing by a lunulate sinus to end of keel, apical tooth slightly curved (not clearly visible without dissection); cells of lobe convex, averaging 19 μ in diameter, with large and conspicuous trigones and occasional intermediate thickenings separated by small pits, convex wall also thickened, cell-cavities varying from rounded to distinctly stellate, base of lobe showing an indistinct group of elongated cells as in *D. subulata;* ocelli none; cells of lobule thickened but without distinct trigones: underleaves distant, basal portion trapezoidal, 0.05 mm. long, 0.04 mm. wide at the base, marginal cells six, the middle one on each side more or less bulging but less distinctly so than in *Leptolejeunea exocellata*, divisions widely spreading, each consisting of two or three cells in a single row, with a spread of 0.07 mm.: cells of underleaf with distinctly thickened walls: inflorescence dioicous: ♀ inflorescence on a short branch, innovating on one side with a simple and sterile innovation; bracts obliquely spreading, complicate, shortly and unequally bifid, the lobe ovate, falcate, 0.5 mm. long, 0.35 mm. wide, obtuse to acute, entire or irregularly repand and denticulate, lobule oblong, 0.25 mm. long, 0.08 mm. wide, truncate, scarcely separated from lobe; bracteole free or nearly so, oblong-obovate, 0.35 mm. long, 0.25 mm. wide, bifid about one third with a broad sinus and triangular acute divisions: perianth and ♂ inflorescence unknown (*pl. 2, f. 1–13*).

On a log. El Yunque, *Evans* (89 *p.p*).

The nearest ally of this new species is apparently *D. subulata.* The two plants resemble each other in their convex leaf-lobes which are erect or approximately so, in the group of elongated cells at the base of the lobe, and in the slightly curved terminal tooth of the lobule. *D. crassiretis* differs from *D. subulata* in its blunter leaves, in its smaller leaf-cells which have thickened convex walls and more conspicuous trigones, in its firmer underleaves with thicker cell-walls and in its less sharply pointed bracts with blunt lobules. Propagula have not as yet been observed in either species.

The type-specimens of *D. crassiretis* grow mixed with *D. biocellata* and the two species have certain characters in common, such as the thickened cell-walls and the blunt leaf-lobes. There is, however, little difficulty in distinguishing them, on account of the ocellate and usually spreading lobes of *D. biocellata*, the less conspicuous local thickenings in its cells, the more strongly curved apical teeth of its lobules, its narrower perichaetial bracts and narrower and more deeply bifid bracteoles.

DREPANOLEJEUNEA ARAUCARIAE Steph.

Drepanolejeunea Araucariae Steph. Hedwigia, **35**: 80. 1896.

Bright green varying to brownish green, growing in thin irregular patches often in company with other Lejeuneae: stems 0.025 mm. in diameter, prostrate, sparingly and irregularly pinnate, the branches widely spreading: leaves distant, the lobe obliquely spreading in the lower part, widely spreading above, plane or slightly concave, falcate-lanceolate, 0.25 mm. long, 0.09 mm. wide, scarcely narrowed at the base and attached by an almost longitudinal line of insertion, margin denticulate, the teeth about three on each side, projecting away from the substratum, each tooth usually a projection from a single cell, the tooth near keel often larger than the others and composed of from one to three cells, apex attenuate ending in two or three cells in a row; lobule strongly inflated, broadly ovate, 0.1 mm. long, 0.07 mm. wide, keel strongly arched, distinctly roughened in outer part from projecting cells, free margin slightly curved, plane and appressed to lobe, passing beyond apex by a lunulate sinus to end of keel, apical tooth more or less curved; cells of lobe plane or nearly so, averaging 14 × 9 μ, thin-walled; ocelli commonly two, one at the very base of the lobe measuring 18 × 14 μ, the other close to the apex of the lobule: underleaves distant, basal portion subquadrate, 0.03 mm. long, marginal cells six, divisions obliquely to widely spreading (up to 0.08 mm.), each consisting of two or three cells in a row: inflorescence dioicous: ♀ inflorescence usually on a short branch, more rarely on an elongated branch, innovating on one side with a simple and sterile innovation; bracts erect-spreading, more or less complicate, unequally bifid, the lobe ovate to ovate-lanceolate, attenuate, coarsely and irregularly laciniate or spinose-dentate, 0.25 mm. long, 0.1 mm. wide, lobule irregular in shape, 0.15 mm. long, 0.07 mm. wide, laciniate; bracteole more or less connate on one side, ovate, 0.2 mm. long, 0.15 mm. wide, bifid about one half with attenuate divisions, margin irregularly spinose-dentate; perianth oblong, five-keeled, keels slightly spinose at the apex, postical keels long and narrowly decurrent, parallel, beak tubular, long for the size of the plant: ♂ inflorescence on a short branch; bracts in one or two pairs, imbricated, strongly inflated, the lobe orbicular, abruptly acute at the apex, lobule subacute, keel roughened in the outer part: antheridia borne singly (*pl. 2, f. 14–23*).

On living leaves. El Yunque, *Evans* (36 *p.p.*, 197). Originally collected in Brazil by *Ule*.

D. Araucariae is related more or less closely to the four following species under which its differential characters will be noted. It may be stated here, however, that it differs from all of them in its smaller size and in its smaller leaf-cells. It is in fact the smallest and most delicate of all known *Drepanolejeuneae* from Puerto Rico. Its propagula offer little that is distinctive. The rudimentary leaves behind which they arise are sometimes borne on specialized axes and are sometimes scattered among normal leaves. The description of the perianth is taken from Stephani.

Drepanolejeunea dissitifolia sp. nov.

Brownish-green, growing in thin irregular patches: stems 0.04 mm. in diameter, prostrate, irregularly pinnate, the branches widely spreading: leaves distant, the lobe obliquely spreading in the lower part, widely spreading above, somewhat convex, falcate-lanceolate, 0.3 mm. long, 0.09 mm. wide, slightly narrowed at the base and attached by an almost longitudinal line of insertion, margin entire or slightly crenulate or denticulate from projecting cells, apex acute to short-acuminate, ending in one cell or in two superimposed cells; lobules strongly inflated, ovate, 0.1 mm. long, 0.07 mm. wide, keel strongly arched, roughened in outer part from projecting cells, free margin slightly curved, involute near base, passing beyond apex by a lunulate sinus to end of keel, apical tooth strongly curved; leaf-cells plane or slightly convex, thin-walled, averaging $16 \times 12\ \mu$; ocelli none: underleaves distant, basal portion quadrate to trapezoidal, 0.045 mm. long, marginal cells usually six to eight, rarely as many as ten, divisions widely spreading, sometimes at an angle of 180°, having a spread of 0.15 mm., each three or four cells long and two cells wide at base:

inflorescence dioicous : ♀ inflorescence unknown : ♂ inflorescence terminal on a short or somewhat elongated branch ; bracts in one to four pairs, closely imbricated and strongly inflated, the lobe obliquely spreading, acute, lobule acute, tipped with a small straight apical tooth separated from the end of the keel by a shallow and subacute sinus : antheridia borne singly (*pl. 3, f. 1–8*).

On living leaves. El Yunque, *Evans* (23 *p.p.*).

The underleaves of *D. dissitifolia* are more complex than in any of the other Puerto Rico species and form one of its most striking peculiarities. They show their complexity in the large number of cells of which they are composed, the widely spreading divisions and the marginal portion of the base both showing more than the usual number. These complex underleaves to be sure are not invariably developed, those on slender axes often showing a smaller number of cells than those on robust axes.

D. dissitifolia is only a trifle larger than *D. Araucariae* which it much resembles in habit. The latter species differs in its distinctly denticulate leaves, in its ocelli, and in the abruptly pointed lobes of its perigonial bracts. *D. dissitifolia* also resembles to a certain extent *D. biocellata* with which the type-specimens are badly mixed. *D. biocellata*, however, is a more robust plant with broader and blunter ocellate leaves and differs further in the thickened walls of its leaf-cells and in its diandrous perigonial bracts.

The propagula of *D. dissitifolia* are borne on branches which are scarcely modified and are frequent both on male and on sterile individuals. In several cases a propagulum which had become established developed a few normal leaves and then passed directly into a male inflorescence without branching. The first leaves and underleaves of the propagula are less specialized than in *Leptolejeunea*, the disc on the first underleaf being small and the second leaf showing a well-developed lobule. In the first few leaves, however, the lobe remains short, extending but slightly beyond the lobule and its postical margin frequently bears from one to three sharp teeth.

Drepanolejeunea bidens (Steph.)

Lejeunea (*Drepano-Lejeunea*) *bidens* Steph. Hedwigia, **29**: 71. 1890.

Yellowish-green, growing in thin and loose patches : stems 0.035 mm. in diameter, prostrate, irregularly pinnate, the branches widely spreading: leaves distant to subimbricated, the lobe suberect or obliquely spreading in the lower part, widely spreading above, convex, falcate-lanceolate, 0.35 mm. long, 0.08 mm. wide, somewhat narrowed toward the base and attached by an almost longitudinal line of insertion, margin subentire or slightly crenulate or denticulate from projecting cells, rarely with a larger blunt tooth near end of keel, apex long-acuminate, ending in a row of two or three cells; lobule strongly inflated at base and along keel, broadly ovate, 0.15 mm. long, 0.1 mm. wide, keel strongly arched, slightly roughened in outer part from projecting cells, free margin plane and appressed to lobe, passing beyond apex by a lunulate sinus to end of keel, apical tooth strongly curved; cells of lobe somewhat convex, their walls slightly but uniformly thickened, averaging 19 × 14 μ; ocelli commonly two, one at the base of the lobe, the other at about the middle, indistinct: underleaves distant, basal portion quadrate or rectangular, 0.03 mm. long, marginal cells six, divisions obliquely to widely spreading (up to 0.07 mm.), each consisting of two or three cells in a single row, rarely two cells wide at base: inflorescence dioicous: ♀ inflorescence borne on a very short branch innovating on one side with a simple and sterile innovation; bracts obliquely spreading, unequally bifid, the lobe ovate, 0.35 mm. long, 0.15 mm. wide. long-acuminate, the margin coarsely and irregularly dentate or spinulose-ciliate, usually with from four to seven teeth, lobule irregular in shape, 0.25 mm. long, 0.08 mm. wide, acute to acuminate, margin as in lobe, but usually with fewer teeth (mostly one to five); bracteole connate on one side, ovate, 0.3 mm. long, 0.15 mm. wide, bifid about one third with erect, subacuminate lobes and narrow sinus, margin as in bracts, usually with from five to twelve teeth in all: perianth broadly obovoid, 0.4 mm. long, 0.3 mm. wide, gradually narrowed toward the base, truncate above and with a short beak, terete below, sharply five-keeled in upper part, the keels projecting outward as subacute, slightly dentate horns; ♂ infloresence unknown (*pl. 3, f. 9–17*).

On rotten wood. North slope of the Luquillo Mountains, *Heller* (1139). El Yunque, *Evans* (4, 196).

The type-specimens of *D. bidens* are in the Lindenberg herbarium at Vienna. They were preserved there under the name "*Lejeunea hamatifolia*" until Stephani proved their distinctness. Nothing definite seems to be known as to where they were collected, their label reading simply (according to Stephani) "in cortice peruv.," but it is probable that they came from tropical America. The species does not seem to be uncommon in the Luquillo Mountains.

Although *D. bidens* is a somewhat smaller plant than *D. hamatifolia*, the two species are closely related. In the latter species, however, the lobes of the leaves are shorter and less attenuate, and the antical margin is usually distinctly dentate, especially in the lower part. The leaf-cells are of about the same size in the two species but in *D. hamatifolia* the trigones are more conspicuous. The underleaves also offer good points of difference, the basal portion in *D. hamatifolia* being often bordered by more than six marginal cells and the widely spreading divisions measuring four or five cells in length and usually two cells in width at the base. In the European species, finally, the leaves are destitute of ocelli and the inflorescence is autoicous.

Among the Puerto Rico species *D. Araucariae* and *D. dissitifolia* are both close to *D. bidens*, as is also the species next described. Aside from the difference in size already noted *D. Araucariae* differs from *D. bidens* in its more distant leaves with more denticulate margins and in its more laciniate bracts and bracteoles. In *D. dissitifolia* also the leaves are more distant than in *D. bidens* and are distinguished further by being exocellate, but in this species the larger and more complicated underleaves offer the best differential characters.

Propagula are so abundantly produced in *D. bidens* that the microphyllous branches upon which they are borne deserve a few words of description. A branch of this character usually bears normal leaves at its base but as we proceed toward the apex we find the leaves gradually becoming smaller and arrested in their development. The aborted leaves are much shorter and narrower than normal leaves, their less attenuate lobes are suberect or obliquely spreading and are never falcate, their lobules are much reduced, in extreme cases consisting simply of a minute tooth borne near the postical base of the lobe. Nearly every one of these aborted leaves gives rise to a propagulum just behind it and as the propagula become detached very readily we can usually observe no signs of them except the basal sheaths which are left behind. The underleaves on the microphyllous branches are smaller than ordinary underleaves, their divisions being only one or two cells long. The propagula themselves are similar to those of *D. dissitifolia* and of other Puerto Rico species. It may be noted here that *D. hamatifolia* also produces propagula which are specialized to only a slight extent; the first underleaf for example although considerably larger than the succeeding one shows only a trace of a disc.

Drepanolejeunea bispinulosa sp. nov.

Pale green, scattered among other hepatics: stems 0.035 mm. in diameter, prostrate, sparingly and irregularly pinnate, the branches widely spreading: leaves distant to subimbricated, the lobe obliquely spreading in lower part, widely spreading above, convex near base, plane or slightly concave beyond lobule, falcate-lanceolate, 0.35 mm. long, 0.1 mm. wide, slightly narrowed toward base and attached by an almost longitudinal line of insertion, margin distinctly crenulate or denticulate from projecting cells except near the base, the tooth near end of keel and the opposite tooth on antical margin larger than the others and spiniform, usually two or three cells long and one or two cells wide at the base, rarely obsolete, apex long-acuminate, ending in a row of three or four cells; lobule strongly inflated throughout, ovate, 0.15 mm. long, 0.1 mm. wide, keel strongly arched, distinctly roughened in the outer part from projecting cells, free margin involute to or beyond the apex, then passing by a lunulate sinus to end of keel, apical tooth strongly curved; cells of lobe slightly convex, the projecting wall slightly thickened, lateral walls variable, sometimes slightly and uniformly thickened, sometimes with small trigones, averaging 17 × 12 μ; ocelli indistinct, usually one in the middle of the lobe, sometimes obsolete: underleaves distant, similar to those of *D. bidens*: remaining parts unknown (*pl. 4, f. 1–7*).

On rotten wood. Luquillo Mountains, *Heller* (4743 *p.p.*).

Drepanolejeunea bispinulosa is very closely related to *D. bidens*, so closely in fact that it may be questioned whether it is really distinct or whether it represents a robust condition of that species. It differs from *D. bidens* in the more distinctly crenulate or denticulate margins of its lobes and especially in their two spiniform teeth. These slight differences give the plants an entirely different appearance from those of *D. bidens*, and so far no connecting links have been observed. Unfortunately the plants are entirely without sexual organs and do not even show propagula.

Almost equally close to *D. bispinulosa* is the Andine *Lejeunea* (*Drepano-Lej.*) *lichenicola* Spruce.* The two species are of about the same size and agree in most of their leaf-characters. In *L. lichenicola* however no spiniform tooth is developed on the antical margin of the lobe. It differs from *D. bispinulosa* also in its underleaves which are characterized by their larger size and more widely spreading divisions, resembling to a certain extent the underleaves of *D. dissitifolia.*

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* Hep. Amaz. et And. 191. 1884.

Drepanolejeunea crucianella (Tayl.)

Lejeunea crucianella Tayl. Lond. Jour. Bot. **5**: 393. 1846.

Lejeunea (*Lepto-Lejeunea*) *crucianella* Spruce, Hep. Amaz. et And. 197. 1884.

Yellowish or brownish-green, growing in thin irregular patches, often in company with other Lejeuneae: stems 0.035 mm. in diameter, closely adherent to substratum, sparingly and irregularly pinnate, the branches widely spreading: leaves distant to contiguous, the lobe obliquely spreading, plane or slightly concave, the antical margin being more or less reflexed, ovate to ovate-lanceolate, 0.3 mm. long, 0.1 mm. wide, slightly narrowed toward base and attached by an almost longitudinal line of insertion, margin sharply and irregularly toothed beyond lobule, the first postical tooth and the opposite antical tooth larger than the others, spiniform, measuring three to five cells in length and one to three cells in width at the base, the succeeding teeth one to four in number on each side, sometimes obsolete, each consisting of one or two cells, apex attenuate, ending in a row of three or four cells, often curved forward; lobule strongly inflated at base and along keel, often plane and appressed to lobe along free margin, broadly ovate, 0.1 mm. long, 0.08 mm. wide, keel strongly arched, smooth or very slightly roughened in outer part from projecting cells, free margin passing beyond apex by a lunulate sinus to the terminal cell of the adnate portion of the lobule, apical tooth curved; cells of lobe plane or nearly so with slightly and irregularly thickened walls, averaging 18 x 14 μ; ocelli inconspicuous and sometimes obsolete, commonly two in each lobe, one near the base, the other near apex of lobule: underleaves distant, basal portion trapezoidal, 0.035 mm. long, marginal cells six, divisions widely spreading (up to 0.1 mm.), each consisting of two or three cells in a single row: inflorescence dioicous: ♀ inflorescence borne on a very short branch innovating on one side with a simple and sterile innovation; bracts obliquely spreading, unequally bifid, the lobe ovate, 0.25 mm. long, 0.13 mm. wide, margin irregularly spinose-dentate or ciliate, apex attenuate, lobule irregular in shape, 0.17 mm. long, 0.08 mm. wide, laciniate; bracteole connate on one side near base, oblong, 0.25 mm. long, 0.13 mm. wide, bifid about two fifths with acuminate and ciliate divisions and narrow sinus; perianth unknown: ♂ inflorescence terminal; bracts in two to five pairs, more or less imbricated, strongly inflated, shortly bifid, the lobe orbicular, abruptly apiculate or blunt at the apex, lobule blunt, keel roughened in outer part; antheridia in pairs (*pl. 4, f. 8–17*).

On living leaves. El Yunque, *Evans* (42 *p.p.*, 43 *p.p.*). Originally collected at Demerara and since found by *Spruce* in Brazil.

The type specimens of *Lejeunea crucianella* in the Taylor herbarium are very fragmentary and are also poorly developed. They agree very well, however, with some of the rudimentary specimens from Puerto Rico, and it seems justifiable to refer the latter to Taylor's species in spite of the unsatisfactory condition of the type. The specimens in the Lindenberg herbarium, preserved under the name *L. crucianella*, are, according to Stephani, a *Cololejeunea* and are referable to his *C. papilliloba*, a species known also from Brazil.*

Apparently *D. crucianella* received its name on account of the peculiar form of the leaves when poorly developed. In these cases the spiniform teeth are almost as conspicuous as in well-developed leaves, while the apical portion of the lobe is scarcely longer than these spreading teeth and is entire or nearly so. This condition is seen especially well in ♂ material and is emphasized in Spruce's description. In well-developed leaves where the apical portion of the lobe is considerably longer than the spiniform teeth and is distinctly toothed on the margin, the specific name loses much of its significance. Spruce placed the species in *Lepto-Lejeunea*, probably on account of its diandrous bracts, but it is so close to several of the species described in the present paper that it ought hardly to be separated from them generically.

Among the Puerto Rico species *D. bispinulosa* is perhaps the most closely related to *D. crucianella*, the two species agreeing in the two spiniform teeth of their lobes. In the latter species, however, the teeth are longer and broader at the base and the portion of the lobe beyond the teeth is much more strongly toothed. The attenuate apex also, instead of spreading widely as in *D.*

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* Hedwigia, 29: 73. 1890; 34: 250. 1895.

bispinulosa, is usually directed forward so that the long axis of the lobe is inwardly instead of outwardly curved. Of course the sharply toothed lobes would at once distinguish *D. cruciandla* from *D. Araucariae* and from *D. dissitifolia*, two species which it resembles in habit, and also from *D. bidens*.

Drepanolejeunea infundibulata (Spruce)

Lejeunea (*Drepano-Lejeunea*) *infundibulata* Spruce, Hep. Amaz. et And. 191. 1884.

Pale green, becoming brownish upon drying, growing in thin irregular patches: stems 0.04 mm. in diameter, closely adherent to substratum, irregularly pinnate, the branches obliquely to widely spreading: leaves distant, the lobe obliquely spreading, plane or with one or both margins slightly revolute near the apex, lanceolate, 0.5 mm. long, 0.15 mm. wide, straight or more or less falcate near apex, somewhat narrowed toward base and attached by an oblique line of insertion, margin entire or slightly denticulate from projecting cells, usually with a larger and sharper tooth composed of several cells near end of keel, apex acute to acuminate; lobule ovate, inflated in basal and carinal portions, usually plane and appressed to lobe along free margin, 0.15 mm. long, 0.09 mm. wide, keel arched, smooth or slightly roughened in outer part from projecting cells, free margin passing beyond apex by a lunulate sinus to end of keel, apical tooth strongly curved; lobule often poorly developed; cells of lobe thin-walled and without trigones, averaging 17 × 13 μ at edge of lobe and 23 × 13 μ in the middle; ocelli none: underleaves distant, basal portion broadly trapezoidal, 0.03 mm. long, marginal cells six, divisions widely spreading, sometimes as much as 180° and with a spread of 0.15 mm., each consisting usually of two cells in a row: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with a simple and sterile innovation; bracts erect-spreading, scarcely complicate, unequally bifid, the lobe lanceolate, 0.4 mm. long, 0.12 mm. wide, acuminate, margin subentire or irregularly denticulate, lobule 0.25 mm. long, 0.07 mm. wide, acute to truncate, margin as in lobe; bracteole connate on one side, oblong-obovate, 0.35 mm. long, 0.14 mm. wide, bifid one fourth to one third with obtuse to acute lobes and acute sinus, margin as in bracts; perianth long-exserted, narrowly obovoid, 0.75 mm. long, 0.35 mm. wide in the middle, narrowed toward the base, truncate above and with a short beak, terete below, sharply five-keeled above, the keels extending outward and upward as acute, more or less spinose horns: ♂ inflorescence occupying a short branch, bracts usually in three to ten pairs, closely imbricated, strongly inflated, shortly bifid, the lobe acute or obtuse, the lobule subacute, keel strongly arched, narrowly but distinctly winged in the upper part, the wing slightly denticulate from projecting cells; bracteoles present at base of spike, small, bifid with erect-spreading lobes and obtuse sinus; antheridia in pairs. (*pl. 5*).

On living leaves. El Yunque, *Evans* (21 *p.p.*, 23 *p.p.*). Originally collected by *Spruce* on Chimborazo.

The type-specimens of *Lejeunea infundibulata* in the Spruce herbarium are exceedingly fragmentary and are badly mixed with *L. campanulata* Spruce, a closely allied species. They are at the same time so weather-worn that it is difficult to gain from them a clear idea of the species. Fortunately Spruce's description is definite and is apparently drawn from better specimens. The plants from Puerto Rico are in good condition and agree closely with the original description and also, so far as one can determine, with the battered type. A single discrepancy with regard to the keels of the perianth may be noted. According to Spruce these are "dilated into broad, acute, almost horizontal subula" and it is implied that they are smooth. In the writer's specimens the keels extend outward as slightly spinose horns. An examination of the type shows, however, that even here the keels are not invariably smooth but are sometimes more or less toothed, so that the species is apparently subject to considerable variation in this respect.

D. infundibulata is very closely related to the African *Lejeunea capulata* Tayl.* but differs in its exocellate leaves. According to Spruce † *L. capulata* occurs in the Amazon region, but the specimens in the Spruce herbarium referred to this species, although very fragmentary, are evidently distinct from the type-material of *L. capulata* in the Taylor herbarium. They seem to be much closer to *D. bidens* or to *L. lichenicola*, but it would be unsafe to refer them definitely to either. At all events the evidence is very inadequate that *L. capulata* is a member of the American flora.

Other species more or less closely allied to *D. infundibulata* are *Lejeunea campanulata*, already mentioned, and the Puerto Rico species, *D. biocellata* and *D. dissitifolia*. *L. campanulata* differs in its ocellate leaves with distinctly denticulate margins and in its much shorter perianth with strongly spinose keels. *D. biocellata* differs in its smaller size, in its ocellate leaves, in its smaller leaf-cells with thicker walls and in lacking the sharp tooth near the end of the keel. *D. dissitifolia* finally is smaller than *D. infundibulata* and is distinguished further by its falcate leaves, by its more complicated underleaves and also by the absence of the sharp tooth.

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* Lond. Jour. Bot. 5: 394. 1846.

† Hep. Amaz. et And. 190. 1884.

Propagula are abundantly produced by *D. infundibulata* and are borne on microphyllous branches similar to those described for *D. bidens*. In extreme cases (*pl. 5, f. 3*) these branches are flagelliform and project at right angles from the substratum. The lobes of their leaves are broadly ovate or subrotund, the margin is quite entire and the apex varies from subacute to rounded. Oftentimes the terminal cell is apiculate. In many cases the reduced leaves are only four or five cells long. The lobules of these diminutive leaves consist of only three or four cells in a row, the terminal cell projecting as a minute tooth and the others being adnate to the lobe. The underleaves on the microphyllous axes develop no rhizoids and are frequently composed of only four cells, two forming the basal portion and the other two the minute and erect divisions.

DREPANOLEJEUNEA INCHOATA (Meissn.) Schiffn.

Jungermannia inchoata Meissn.; Lehmann, Pugillus, **5**: 19. 1833.

Lejeunea inchoata Meissn.; G. L. & N. Syn. Hep. 343. 1845.

Lejeunea epitheta Tayl. Lond. Jour. Bot. **5**: 395. 1846 (*teste* Stephani).*

Lejeunea (*Drepano-Lejeunea*) *inchoata* Spruce, Hep. Amaz. et And. 187. 1884.

Lejeunea (*Drepano-Lejeunea*) *planiuscula* Spruce, *l. c.*, 192. 1884 (*teste* Stephani).*

Drepanolejeunea inchoata Schiffn.; Engler & Prantl, Nat. Pflanzenfam. **1**^{3}: 126. 1893.

Plants green, becoming brownish upon drying, growing in thin irregular patches: stems 0.06 mm. in diameter, closely adherent to substratum, irregularly pinnate, the branches widely spreading: leaves (when well developed) loosely imbricated, the lobe obliquely spreading, plane or inflexed at the apex, falcate-ovate or falcate-rotund from a narrow base, 0.75 mm. long, 0.4 mm. wide, attached by a short, almost longitudinal line of insertion abruptly curving toward the middle of the axis in the upper part, antical margin more or less concave toward base, then strongly convex to apex, postical margin straight or slightly convex, apex acute, whole margin (except concave portion) coarsely and irregularly dentate, the teeth numerous especially along antical margin, often as many as twenty-five for the whole lobe, sharp, sometimes consisting of single projecting cells sometimes of small groups of cells, sinuses separating teeth lunulate; lobule inflated in basal and carinal portions, usually plane and appressed to lobe along free margin, oblong-ovate, 0.25 mm. long, 0.14 mm. wide, keel slightly arched, smooth or nearly so, free margin almost straight as far as apex, then passing by a broad lunulate sinus to end of keel, apical tooth strongly curved; leaves often poorly developed; cells of lobe plane, with more or less confluent trigones and intermediate thickenings, averaging 15 μ in diameter at edge of lobe, 24 μ in the middle and $46 \times 28\ \mu$ at the base; ocellus single, often indistinct or obsolete, situated in the lower part of the lobe close to the apex of the lobule: underleaves distant, basal portion broadly trapezoidal, 0.05 mm. long, marginal cells six, divisions widely spreading (up to 0.25 mm.), usually three cells long and one or two cells wide at the base: inflorescence dioicous: ♀ inflorescence borne on a very short branch, innovating on one side with a simple or branched innovation; bracts erect-spreading, scarcely complicate, unequally bifid, the lobe ovate, 0.4 mm. long, 0.2 mm. wide, acute or acuminate, margin irregularly dentate to subentire, lobule 0.3 mm. long, 0.08 mm. wide, acute or bidentate at the apex, margin as in lobe; bracteole connate on one or both sides, linear to ovate, 0.4 mm. long 0.2 mm. wide, bifid about one third with lanceolate, acuminate lobes separated by a narrow sinus, margin as in bracts; perianth about two thirds exserted, oblong-obovoid from a narrowed base, 0.6 mm. long, 0.3 mm. wide in the middle, truncate at the apex and with a very short or obsolete beak, terete below, sharply five-keeled above, the keels projecting outward as sharp, dentate to spinose horns, with usually one to four teeth or spines on each: ♂ inflorescence occupying a short branch; bracts usually in three to eight pairs, closely imbricated, strongly inflated, shortly bifid with acute divisions, keel strongly arched with a narrow crenulate wing; bracteoles present at base of spike, bifid with suberect divisions separated by a broad lunulate sinus (*pl. 6*).

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* Hedwigia, **35**: 83. 1896.

On living leaves. First collected by *Schwanecke*. El Yunque, *Evans* (40, 41, 117). Type-locality, "in ins. Caraib. ad Filices." Now known from several of the West Indian islands, from Costa Rica and from various localities in South America.

D. inchoata may be at once distinguished from all the other Puerto Rico species of *Drepanolejeunea* by its large size and by its broad and coarsely dentate leaves, abruptly dilated from a narrow base. The description as given above is drawn mainly from robust specimens where the leaves attain their best development. On slender axes the leaves are smaller and narrower and their lobules are often inflated throughout; sometimes the lobules are rudimentary. These small-leaved branches must be distinguished from the flagelliform branches which bear the propagula. The latter are similar to those of *D. infundibulata* but their leaves are a little better developed. In his description of *L. planiuscula* Spruce calls attention briefly to these flagelliform branches but gives no hint as to their real significance. He also mentions "a form beset with a thick coating of adventitious ramuli, arising either from the leaves or (rarely) from the branches." They are said to "bear leaves reduced almost entirely to the basal sac, beyond which the lobe projects as a small triangular dentiform limb." These ramuli, which are apparently homologous with the propagula of *Plagiochila*, have not been observed in any of the Puerto Rico specimens.

So far as known the closest ally of *D. inchoata* is the paleotropic *D. setistipa* Steph., of Java, a species which was long confused with the American plant. The two species resemble each other very closely in their leaf-characters and differ mainly in their underleaves and perianths. The differences are well brought out by Stephani's description* and by the somewhat earlier figures of Schiffner.† In *D. setistipa* the divisions of the underleaves are very divaricate, sometimes spreading at an angle of more than 180°; according to Schiffner's figures they measure six or seven cells in length and are two cells wide in the lower part. The basal portion of the underleaf is bounded by considerably more than six marginal cells. The perianth of *D. setistipa* is distinguished by its unarmed horns.

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* Hedwigia, **35**: *83.* 1896.

† Nova Acta Acad. Caes.-Leop. **60**: *pl. 8. f. 5–8.* 1893.

YALE UNIVERSITY.

Explanation of Plates

As in the first paper of this series, the figures were drawn by the writer and prepared for publication by Miss Hyatt.

PLATE 1

Drepanolejeunea biocellata Evans. 1. Part of stem, postical view, × 70. 2. Part of stem, antical view, × 70. 3. Cells from middle of lobe, × 400. 4–6. Apices of lobes, × 280. 7. Cells from margin of lobe, × 280. 8. Apex of lobule, × 280. 9. Underleaf, × 280. The figures were all drawn from the type-specimens.

Drepanolejeunea subulata Steph. 10. Part of stem, postical view, × 45. 11. Leaf, antical view, × 45. 12. Cells from middle of lobe, × 400. 13. Apex of lobe, × 280. 14. Base of lobe, × 280. 15. Apex of lobule, × 280. 16. Underleaf, × 280. 17, 18. Bracts, × 70. 19. Bracteole, × 70. The figures were all drawn from specimens collected by A. A. Heller (no. 4712).

PLATE 2

Drepanolejeunea crassiretis Evans. 1. Part of sterile stem, postical view, × 75. 2. Part of stem, antical view, × 75. 3. Leaf, flattened out, × 75. 4. Cells from middle of lobe, × 440. 5–7. Apices of lobes, × 310. 8. Cells from margin of lobe, × 310. 9. Apex of lobule, × 310. 10. Underleaf, × 310. 11, 12. Bracts, × 75. 13. Bracteole, × 75. The figures were all drawn from the type-specimens.

Drepanolejeunea Araucariae Steph. 14. Part of stem with ♀ inflorescence, postical view, × 75. 15. Part of sterile stem, antical view, × 75. 16. Part of stem with ♂ inflorescence, postical view, × 75. 17. Cells from middle of lobe, × 440. 18. Apical half of lobe. × 310. 19. Apex of lobule, × 310. 20. Underleaf, × 310. 21, 22. Bracts, × 75. 23. Bracteole, × 75. The figures were all drawn from the specimens collected by the writer (no. 36).

PLATE 3

Drepanolejeunea dissitifolia Evans. 1. Part of plant, postical view, × 70. 2. ♂ inflorescence, antical view, × 70. 3. ♂ inflorescence, postical view, × 70. 4. Cells from middle of lobe, × 400. 5. Apex of lobe, × 280. 6. Apex of lobule, × 280. 7, 8. Underleaves, × 280. The figures were all drawn from the type-specimens.

Drepanolejeunea bidens (Steph.) Evans. 9. Part of plant with ♀ inflorescence, postical view, × 70. 10. Leaf, antical view, × 70. 11. Cells from middle of lobe, × 400. 12, 13. Apices of lobes, × 280. 14. Apex of lobule, × 280. 15. Underleaf, × 280. 16. Bract with connate bracteole, × 70. 17. Bract, × 70. All the figures were drawn from specimens collected by A. A. Heller (no. 1139).

PLATE 4

Drepanolejeunea bispinulosa Evans. 1. Part of stem, postical view, × 70. 2. Part of stem, antical view, × 70. 3. Cells from middle of lobe, × 400. 4. Apex of lobe, × 280. 5. Cells and spiniform tooth from antical margin of lobe, × 280. 6. Apex of lobule, × 280. 7. Underleaf, × 280. The figures were all drawn from the type-specimens.

Drepanolejeunea crucianella (Tayl.) Evans. 8. Part of plant with ♀ inflorescence, postical view, × 70. 9. Branch with ♂ inflorescence, postical view, × 70. 10. Part of stem, antical view, × 70. 11. Cells from middle of lobe, × 400. 12 Upper part of lobe, × 280. 13. Apex of lobule, showing opening into water-sac, × 280. 14. Apex of lobule, × 280. 15. Underleaf, × 280. 16. Bract, × 70. 17. Bracteole, × 70. All the figures were drawn from specimens collected by the writer (nos. 42, 43).

PLATE 5

Drepanolejeunea infundibulata (Spruce) Evans. 1. Part of plant with perianth, postical view, × 47. 2. Part of sterile stem, postical view, × 47. 3. Flagelliform branch with two propagula, × 72. 4. Leaf, antical view, × 47. 5. Cells from middle of lobe, × 425. 6. Tooth on postical margin, × 300. 7. Apex of lobe, × 300. 8. Apex of lobule, × 300. 9. Underleaf, × 300. 10. Bract and connate bracteole, × 72. 11. Bract, × 72. The figures were all drawn from specimens collected by the writer (no. 21).

PLATE 6

Drepanolejeunea inchoata (Meissn.) Schiffn. 1. Part of stem with two perianths and a ♀ inflorescence, postical view, × 44. 2. Part of sterile stem, postical view, × 44. 3. Leaf, antical view, × 44. 4. Cells from middle of lobe, × 370. 5. Apex of lobe, × 265. 6. Apex of lobule, × 265. 7, 8. Underleaves, × 265. 9, 10. Bracts with connate bracteoles, × 65. The figures were all drawn from specimens collected by the writer (no. 41).

An Index to the described Species of Botrychium

By Lucien Marcus Underwood

During seven years of special but more or less interrupted study of the genus *Botrychium* added to a field experience with various members of the genus extending over a quarter of a century, we have been able to see the most important collections of the world and have received a great quantity of material from numerous correspondents. Besides practically all the herbaria of this country, the foreign collections at Kew, London, Berlin, and Paris have been studied with care. As a result of this study not only have our former convictions regarding the status of the various members of the *ramosum* and *ternatum* groups been confirmed, but additional species in both these groups, together with two new representatives of the *Virginianum* group can now be properly segregated.

With the most recent publication of an African species, some members of the genus are now found on every continent and in every zone in which a land-area exists. The first index to the species was published by Milde,* who early gave an elaborate account of the variations of the species known to him. Great authority has hitherto been attributed to his opinions, which he published a generation ago, but it must ever be remembered that he based his conclusions, except among the central European species which he knew in the field, on exceedingly meagre data. This is especially true of American material, particularly among the smaller species of the genus. The same condition remains true to this day regarding the greater part of the collections of continental Europe. When we examined the collection at Berlin in 1898 it contained only a single American specimen of *Botrychium lanceolatum* and that from Greenland, and not a single specimen of *B. neglectum.* Milde's collection was scarcely better, to judge it by his own citations, and the futility of relying on opinions based on such meagre data becomes clearly apparent when we know the real facts in the case. We mention this because we have had in this country in certain quarters too much of the now obsolete notion that "the Europeans have told us better" concerning the status of our own species. Milde recognized only ten species in 1870. Prantl * enumerated the species known to him in 1884, and although he was familiar with the principal German collections only, he still recognized fifteen species. Against these more rational estimates, the English botanists even in their latest pronouncement † can find only six species! The present list enumerates thirty-four species whose status is quite definitely known, and four others concerning which there are no materials for verification that have been accessible up to the present time. Besides the above there is material at Kew and Berlin representing certainly one and possibly two additional species of the *ternatum* group from South America, and perhaps a third from Central America. This material can best await further study before publication. There is also evidence of a species of the *simplex* group in California that awaits further study afield.

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* Verhandl. k. k. zool.-bot. Gesell. Wien. **18** : 507–516. 1868.

LIST OF THE KNOWN SPECIES OF BOTRYCHIUM

Species accepted as valid are in SMALL CAPITALS, except those herein described as new, which are in the usual **bold-faced type**. Species regarded as synonyms of other species are in *italics* with their proper equivalents. Species of uncertain standing owing to inaccessibility of types or other causes are also in *italics*, but with no equivalents indicated.

Botrychium anthemoides Presl = ? B. VIRGINIANUM.

Milde comments on this species in his paper on the Silesian ferns and gives a figure of Presl's specimen, but unfortunately gives two numbers alike on the plate, so as to leave one in doubt concerning just which is the one intended for Presl's plant. There is, however, little doubt but that the species was based on an aborted specimen of the European form of our familiar species.

BOTRYCHIUM AUSTRALE R. Br., Prodr. Fl. Nov. Holl. 164. 1810. —Australia, Tasmania, New Zealand.

Botrychium Baeckeanum Brockm. Archiv. Ver. Freund. Naturg. Mecklenburg, 170. 1863.—Description not seen; said by Milde to belong to *B. matricariae.*

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* Jahrb. Bot. Gartens Berlin, 3 : 297–350. 1884.

† Annals Bot. 5 : 500. 1891.

BOTRYCHIUM BIFORME Colenso, Trans. New Zeal. Inst. **18**: 223. 1886.—New Zealand.

BOTRYCHIUM BITERNATUM (Lam.) Underw. Bot. Gazette, **22**: 407. *pl. 21.* 1896.

Osmunda biternata Lam. Encyc. Meth. Bot. **4**: 650. 1797.

Botrypus lunarioides Rich.; Michx. Fl. Bor. Am. **2**: 274. 1803.

Botrychium lunarioides Sw. Syn. Fil. 172. 1806.

Botrychium fumarioides Willd. Sp. Pl. **5**: 63. 1810.

Botrychium fumariae Spreng. Syst. Veg. **4**: 23. 1827.

South Carolina, Georgia, Florida, Alabama, Louisiana.

BOTRYCHIUM BOREALE Milde, Bot. Zeitung, **15**: 880. 1857.—Scandinavia, Northern Asia, Alaska.

Botrychium brachystachys Kunze = B. VIRGINIANUM MEXICANUM.

Botrychium brevifolium Ångstr. Bot. Notiser, 40. 1866.—Plant not known. Description even not yet seen and the plant was unknown to Milde.

Botrychium Breynii Fries = B. MATRICARIAE.

BOTRYCHIUM CHAMAECONIUM Bitter & Hieron.; E. & P. Nat. Pflanzenf. **1**^{4}: 471. 1900.—Africa (Kamerun).

BOTRYCHIUM CICUTARIUM Sw. Syn. Fil. 171. 1806.—Santo Domingo.

This species was based on Plumier, *pl. 159*, from Santo Domingo. Later writers have confused various species with it, as J. D. Hooker,* who applied the name to a New Zealand species of the *ternatum* group! Moore made it a sub-species of *B. Virginianum.* To this day, however, no specimens of *Botrychium* have been collected in Santo Domingo to our knowledge, and until that *terra incognita* is made known to us botanically it is best to leave the species in abeyance.

BOTRYCHIUM COULTERI Underw. Bull. Torrey Club, **25**: 537. 1898.—Yellowstone National Park, Montana, Wyoming, Idaho.

BOTRYCHIUM CRASSINERVIUM Rupr.; Milde, Nov. Act. Acad. Caes. Leop. Carol. **26**: 763. *pl. 55. f. 10, 11.* 1858.—Siberia.

Botrychium cuneatum Desv. = B. OBLIQUUM.

BOTRYCHIUM DAUCIFOLIUM Hook. & Grev. Ic. Fil. **2**: *pl. 161.* 1831.

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* Handb. New Zeal. Fl. 387. 1867.

Botrychium subcarnosum Wall. Cat. no. 49 (*nomen nudum*); Hook. & Grev. Bot. Misc. **3**: 222. 1833.

India, Burma, Society Islands ?, Samoa ?.

Botrychium daucifolium β Japonicum Prantl = B. JAPONICUM.

BOTRYCHIUM DECOMPOSITUM Mart. & Gal. Mem. Acad. Sci. Bruxelles, **15**:—(15). *pl. 1.* 1842.—Mexico.

Botrychium dichronum sp. nov.

A moderately tall plant, allied to *B. Virginianum*, with sessile sterile lamina and persistent leaf of the preceding year. Roots fleshy: stem 15–20 cm. long, smooth: sterile lamina broadly triangular, 20 cm. wide, 15 cm. long, tripinnatifid with about five pairs of nearly opposite gradually diminishing pinnae, the lowermost with longer pinnules on the outer side and inclined forward at an angle; pinnules 8–10 on each side of a winged rachis, alternate, cut nearly to the midrib into 6–10 segments set at an angle of 45° with the rachis, the lower ones slightly narrowed at the base, and 3–5-toothed at the apex, all gradually simpler towards the apex of the lamina: panicle * triangular, spreading, 3 cm. or more long on a slender stalk 4 cm. or more long, 2–3-pinnate.

JAMAICA: Morce's Gap, altitude 1500 m., 7 Feb. 1900. *W. N. Clute, 96.* (Type in herb. Underwood.)

This plant was distributed as *B. Virginianum* with which it had been previously confounded and which it resembles rather closely, but differs in its peculiar short panicle, in the cutting of the lamina, and especially in its persistent sterile leaf which remains fresh until the new one is fully developed, the plant thus having two growing leaves at the time of maturity to which allusion is made in the specific name. This peculiar habit has been mentioned by both Jenman and Clute, who appear to be the only persons who have reported it from Jamaica. Its seasonal appearance also is peculiar.

BOTRYCHIUM DISSECTUM Spreng. Anleit. **3**: 172. 1804.

Botrychium ternatum, var. *dissectum* D. C. Eaton, Ferns N. A. **1**: 150. *pl. 20. f. 1.* 1878.

New England to Virginia, Ohio, Indiana and Kentucky.

While this species undoubtedly approaches in some of its forms to *B. obliquum*, we have yet to see a specimen that could not readily be distinguished in the herbarium even when shriveled by drying; in the field it often grows in the same localities as *B. obliquum* and there can always be distinguished at a glance. When it grows in the open sun it often becomes contracted and compact in habit, but the typical form of the species is so unlike *B. obliquum* that it is more rational to consider it a distinct species. (*Cf.* observations under *B. ternatum.*)

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* On the type specimen the sporophyll is not quite mature and the measurements may be a trifle too small for an average mature plant.

Botrychium erosum Milde, Bot. Zeitung, **22**: 102. 1864.

(Type from Auckland, New Zealand, *Hay*; in herb. k. k. Hofmuseum, Vienna). Milde later referred this species to his all-embracing *B. ternatum*, but this reference signifies nothing in this day of more rational conceptions of geographic distribution; without having seen the type it seems best to leave the species in doubt though it may be one of the forms of the Australasian *B. australe.*

Botrychium fumariae Spreng. = B. BITERNATUM.

Botrychium fumarioides Willd. = B. BITERNATUM.

Botrychium gracile Pursh = B. VIRGINIANUM.

BOTRYCHIUM JAPONICUM (Prantl) Underw. Bull. Torrey Club, **25**: 538. 1898.

Botrychium daucifolium β Japonicum Prantl, Jahrb. Bot. Gartens Berlin, **3**: 340. 1884.

Japan.

BOTRYCHIUM JENMANI Underw. Fern. Bull. **8**: 59. 1900.—Jamaica.

Botrychium Kannenbergii Klinsman = B. SIMPLEX.

BOTRYCHIUM LANCEOLATUM (S. G. Gmel.) Ångstr. Bot. Notiser, 68. 1854.

Osmunda lanceolata S. G. Gmel. Nov. Comm. Acad. Sci. Petrop. **12**: 516. *pl. 11. f. 2.* 1768.

Botrychium palmatum Presl, Suppl. Tent. Pterid. 43. 1845.

Scandinavia, Siberia, Alaska, to Washington, eastward to Greenland, Labrador and Newfoundland and southward to Colorado, Michigan and Pennsylvania.

BOTRYCHIUM LANUGINOSUM Wall. Cat. 48 (*nomen nudum*); Hook. & Grev. Ic. Fil. **1**: *pl. 79.* (*pl. jun.*) 1831. — India.

BOTRYCHIUM LUNARIA (L.) Sw. Schrader's Jour. Bot. **1800**^{2}: 110. 1801.

Osmunda Lunaria L. Sp. Pl. 1064. 1753.

Europe, Northern Asia, Newfoundland, Labrador, Minnesota, Colorado, Utah, and northward to Alaska and Greenland.

Botrychium lunarioides (Rich.) Sw. = B. BITERNATUM.

BOTRYCHIUM MATRICARIAE (Schrank) Spreng. Syst. Veg. **4**: 23. 1827.

Osmunda matricariae Schrank, Baier. Fl. **2**: 419. 1789.

Botrychium rutaceum Sw. Schrader's Jour. Bot. **1800**^{2}: 110. 1801.

Botrychium matricarioides Willd. Sp. Pl. **5**: 62. 1810.

Botrychium rutaefolium A. Br.; Döll. Rhein. Fl. 24. 1843.

Botrychium Breynii Fries, Summa Veg. Scand. 252. 1846.

? *Botrychium Baeckeanum* Brockm. (*fide* Milde).

Northern Europe, Labrador, Quebec, New Brunswick, Maine, New Hampshire ?, Vermont, New York.

Botrychium matricariaefolium A. Br. = B. RAMOSUM.

Botrychium matricarioides Willd. = B. MATRICARIAE.

BOTRYCHIUM NEGLECTUM Wood, Class Book Botany, [ed. 3.] 816. 1860. — Nova Scotia to Maryland, Ohio and northward; also in South Dakota, Alaska, British Columbia, and Washington ?

BOTRYCHIUM OBLIQUUM Mühl.; Willd. Sp. Pl. **5**: 62. 1810.

Botrychium cuneatum Desv. Ann. Soc. Linn. Paris, **6**: 195. 1827.

Botrychium ternatum var. *obliquum* D. C. Eaton, Ferns N. A. **1**: 149. *pl. 20. f. 2.* 1878.

New Brunswick to Georgia, Indiana and Minnesota.

BOTRYCHIUM OBLIQUUM INTERMEDIUM Underw. Our Native Ferns, ed. 6, 72. 1900.

Botrychium ternatum, var. *australe*, sub-var. *intermedium* D. C. Eaton, Ferns N. A. **1**: 149. *pl. 20a* (*front figure only*). 1879.

New England, New York and northward. The relations of this perplexing form and its distribution are still unsettled questions.

BOTRYCHIUM OCCIDENTALE Underw. Bull. Torrey Club, **25**: 538. 1898. — British Columbia, Washington.

Botrychium Onondagense sp. nov.

A slender species somewhat intermediate between *B. Lunaria* and *B. tenebrosum* with distant wedge-shaped segments. Roots slender from a very short axis: common stalk slender, rather weak and spreading, 8–12 cm. long: lamina short-stalked (about 1 cm.), 2–4 cm. long, 1–1.5 cm. wide, composed of 7–9 broadly cuneate segments which are spaced their own width or more, with one or more notches in the outer margin, or occasionally quite deeply incised: sporophyll 1.5–2.5 cm. long, mostly bipinnate, with a slender stalk 2.5–4 cm. long.

Rocky ground in shade. The following specimens have been examined: "Geddes Farm," Syracuse, 1879, *J. S. Gifford*, C D *; Syracuse, 1873, *E. W. Mundy*, G; Jamesville Road, 1878, *Mary Olivia Rust*, U C D K E; near Split Rock, Syracuse, *Underwood* (type), U. All the stations are within five miles from Syracuse in Onondaga county, New York, where the writer first commenced the study of ferns in 1875, and to the memory of which as one of the most prolific fern localities in the country this species is dedicated. Similar plants have been collected in Michigan near Copper Harbor, Keweenaw Point, *O. A. Farwell*, U; and in Montana, Box Elder Creek, 23 July 1886, *R. S. Williams*, E.

This interesting species was originally discovered by the ladies of the Syracuse Botanical Club in June 1872; there appears to have been some difference of opinion as to whom the original discovery belongs as it was claimed by both Mrs. S. M. Rust and Miss Jane Hosmer. Mr. Davenport was the first to determine the plant and naturally confused it with the more robust *B. Lunaria* and as early as 1877 published an account of it under that name. That it may be a descendant of the stock from which *B. Lunaria* sprang, is possible, but it also has very striking relations with *B. tenebrosum*. Having collected this rare species in one of its central New York stations and being familiar with the European *B. Lunaria* not only in the herbarium but from considerable field study, we have long regarded this a distinct species, and have waited in vain for additional information before publication. We have carefully gone over the extensive suites of specimens of *B. Lunaria* in the large herbaria at Kew, Berlin, and Paris and find nothing to match this slender plant from central New York. The

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* [As noted in previous papers by Professor Underwood, published in the BULLETIN, these letters refer to the herbaria in which the specimens noted have been seen: B = Berlin; C = Columbia (and the N. Y. Botanical Garden); D = Davenport; E = D. C. Eaton; G = Gray; K = Kew; and U = Underwood.—ED.]

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more slender habit, and the distant cuneate segments will readily distinguish it from *B. Lunaria.* The European species also occurs in British America and Alaska and in the high mountains of Colorado. The smaller species of this genus present as close a series as the much larger *ternatum* group and should receive more thorough field study. In this species the leaf is rarely quite short-stalked and in one or two specimens seen the number of segments is abnormally increased to fifteen. On the whole, the plant is rather nearer *B. tenebrosum*, but differs in its broader cuneate segments which are entire or flabellately lobed. In its habitat in rocky woods it is quite unlike *B. Lunaria* of Europe, which commonly grows in open meadows.

Botrychium palmatum Presl = B. LANCEOLATUM.

BOTRYCHIUM PUMICOLA Coville; Underw. Our Native Ferns, ed. 6. 69. 1900; Bull. Torrey Club, **28**: 109. *pl. 7.* 1901.—Oregon.

Botrychium pusillum sp. nov.

A low plant related to *B. matricariae*, branching below the surface of the ground and bearing small ternately compound leaves. Stem 1 cm. long (rarely longer when growing deeply), buried, pale: leaves about 3 cm. wide by 2.5 cm. long, on a short petiole 1–1.5 cm. long, the lateral divisions tripinnatifid, the terminal scarcely exceeding the lateral, the ultimate segments closely placed, rounded, wider and sometimes lobed above, 2.5–3 mm. broad, with entire margins; texture fleshy; veins imperceptible: sporophylls 4–8 cm. long (including the stout stalk), the panicle tripinnate, 3–5 cm. long.

MEXICO: Wet meadows, Sierra de las Cruces, State of Mexico, 3000 m., 11 Sept. 1892, *Pringle, 5192.* (Type in herb. Underwood.)

Differs from *B. biternatum* in its seasonal development, being autumnal instead of vernal, in its stalked leaves, and its more compact fleshy entire segments. Related more nearly to *B. matricariae* in size, but differing in its stouter form, its entire segments, and its concealed veins.

BOTRYCHIUM RAMOSUM (Roth) Ascherson, Fl. Brand. **1**: 906. 1864.

Osmunda ramosa Roth, Fl. Germ. **1**: 444. 1788.

Botrychium matricariaefolium A. Br.; Döll. Rhein. Fl. **24**.

Botrychium Reuteri Payot, Cat. Foug. 15. 1860.

Northern Europe. Early figured by Breyn, and differing entirely both in habit and structure from its American congener which has been confused with it.

Botrychium Reuteri Payot = B. RAMOSUM.

Botrychium robustum (Rupr.).

Botrychium rutaefolium var. *robustum* Rupr.; Milde, Nov. Act. Acad. Caes. Leop.-Carol. **26**: *763. pl. 55. f. 9.* 1858.

Kamtschatka, Unalaska.

Botrychium rutaceum Sw. = B. MATRICARIAE.

Botrychium rutaefolium A. Br. = B. MATRICARIAE.

Botrychium Schaffneri sp. nov.

A stout fleshy plant allied to *B. obliquum* with somewhat compact glaucous foliage and copious elongated sporophylls. Stems 2–5 cm. long, stout, fleshy: leaves 10–18 cm. wide by 6–11 cm. long, on slender petioles 5–6 or rarely up to 10 cm. long; lateral divisions rather long-stalked, tripinnate; the terminal larger, sometimes quadripinnatifid below; ultimate segments oval or rarely lobed and slightly narrowed below, the margins entire, the rachises broadly winged, the surfaces bluish glaucous: sporophylls 20–35 cm. or more long on stout stalks, the panicles 6–12 cm. or more long, quadripinnate.

MEXICO: "In montibus prope San Luis Potosi," Oct. 1879, *Schaffner*, U (type) K; San Miquelito Gebirge (San Luis Potosi), *Schaffner*, *25*, C (numerous specimens); Valle de Mexico, 1875, *Schaffner*, B.

The plant is considerably smaller, more fleshy and glaucous than *B. decompositum* and is correspondingly more compact in growth and has usually shorter petioles. It is much more finely divided than either that species or *B. obliquum* to which it is somewhat related. I take pleasure in naming the species after its sole collector, Dr. Schaffner, who sent me fine specimens over twenty years ago, shortly before his death.

BOTRYCHIUM SILAIFOLIUM Presl. Rel. Haenk. **1**: *76.* 1825.— California and northward.

Botrychium Silesiacum Kirschlg. Fl. Alsac. 401. 1855. Not known and description not seen.

BOTRYCHIUM SIMPLEX Hitchc. Am. Jour. Sci. **6**: 103. *pl. 8.* 1823.

Botrychium Kannenbergii Klinsman, Bot. Zeitung, **10**: 378. **1852.**

New England, New York, New Jersey, Pennsylvania, ? Wyoming; Northern Europe.

Botrychium strictum sp. nov.

A tall plant with the habit of *B. Virginianum* with a sessile sterile lamina and slender spicate panicle. Roots fleshy: stems 25 cm. or more long, slender, with slightly fibrillose covering: sterile leaf broadly triangular, sessile, of three equal or subequal 2–3 pinnatifid divisions; primary pinnae 6–10 cm. long, strongly decurrent on the rachis, with 8–10 pinnules on each side which vary from oblong-lanceolate to lanceolate; pinnules varying from deeply 4–5-crenate to 5-cleft on each side, blunt or rounded at the end: panicle 6–13 cm. long, on a slender stalk 5–6 cm. long, with 16–20 short compact branches 5–15 mm. long, placed at an acute angle with the axis, thus causing the entire panicle to appear spike-like: sporangia much crowded, large, nearly 1 mm. in diameter: spores pale yellow.

JAPAN: Sapporo in groves, Aug. 1894, *A. W. Stanford* (type in the herbarium of the New York Botanical Garden); "in sylvis Takaosan., prov. Musashi, 10 Oct. 1885" comm. J. Matsamura, U. I have also seen a specimen in the Museum of the *Jardin des Plantes* at Paris, and one in the herbarium of Mr. B. D. Gilbert. The species has hitherto been reported from Japan under the name of *B. Virginianum* but it is clearly a very distinct species, differing widely in the cutting of the leaf and in the narrow spike-like panicle which is also much shorter than in our familiar species. In the new species the mature panicle scarcely overtops the sterile leaf when laid on the herbarium sheet.

BOTRYCHIUM SUBBIFOLIATUM Brack. U. S. Expl. Exped. **16**: 317. *pl. 44. f. 2.* 1854. — Sandwich Islands.

Botrychium subcarnosum Hook. & Grev. = B. DAUCIFOLIUM.

BOTRYCHIUM TENEBROSUM A. A. Eaton, Fern Bull. **7**: 8. 1899. — New Hampshire, Vermont, Connecticut, New York.

Botrychium tenellum Ångstr. Bot. Notiser, = B. RAMOSUM (*pl. jun.*).

Botrychium tenuifolium sp. nov.

A slender-stemmed species allied to *B. obliquum* but with the segments thin and reduced to nine in number. Stem very slender, 2–4 cm. long, 1–1.5 mm. thick: leaf 3.5–5 cm. long, 3–6 cm. wide, usually consisting of only nine segments (*i. e.*, strictly biternate), with the three divisions subequal; occasionally larger forms show a pair of additional lobes on the terminal division; segments ovate, 1.2–15 cm. long by 6–8 mm. wide, thin, sharply serrate, or in larger forms occasionally two or three times incised; petiole 3–6.5 cm. long, very slender: panicle 3–6 cm. long, bipinnate or rarely tripinnate below, on a slender stalk 6–22 cm. (usually 12–14 cm.) long.

Specimens have been examined as follows:

LOUISIANA: Alexandria, *Hale* (Chapman herbarium), C (type).

FLORIDA: "River banks," C. Communicated many years ago to Torrey who had endorsed it: "Seems to come near *B. simplex* Hitch."

ALABAMA: Auburn, 1895, *Underwood*, U; 15 Oct. 1896, *Earle*, C; 22 Oct. 1896, *C. F. Baker*, C; Oct. 1897, *Baker & Earle*, C.

MISSOURI: Butler county, 4 Nov. 1892, *Bush*, C.

This species is nearest related to *B. obliquum* which it appears to replace in the coastal plain of the gulf region. It is much more slender than *B. obliquum* and the leaf is not only much less divided in mature forms, but is also thinner and usually sharply serrate almost as in *B. Japonicum.* Typical forms have only nine segments to the leaf.

BOTRYCHIUM TERNATUM (Thunb.) Sw. Schrader's Jour. Bot. **1800**^{2}: 111. 1801.

Osmunda ternata Thunb. Fl. Jap. 329. *pl. 32.* 1784.

Japan, China, India.

A number of species were referred to this species as varieties by Milde, and the practice is still followed by some of his modern admirers. There seems to be no difference of opinion relative to the existence of the groups of individuals as distinct groups, the only difference appearing to be the rank that shall be assigned to them. The *ternatum* group represents a closely allied group of forms that appear to have become widely scattered from some common center. There is no rational doubt but that they have had a common origin; this of course is the only possible explanation of their structural and habital relationship. Now where was the original center from which they sprung? According to the system that would make them varieties of *B. ternatum* because that species *happened* to be the first described, it would seem to follow that that centre was in Japan, otherwise they could not be varieties of a Japanese species. The current system of naming varieties is a stupid practice handed down to us from the past and is wholly at variance with the modern conceptions of evolution. The original centre in all probability was *not* in Japan so that the members of the *ternatum* group are not varieties sprung from *B. ternatum*, and it creates a false impression to continue to call them so. They are distinct *things* as everyone admits, and we maintain it is more rational and more in accord with our conceptions of evolutionary origin from a common stock to call them species. It is also much simpler and leaves us free to determine the original centre of distribution and relationship without prejudice. The practice of naming varieties on slight environmental characters ought to cease, and botanists should discourage the naming of such trivialities. A marked example of how far this reduction of species to varieties can be carried is seen in Dr. Christ's reduction of *Dryopteris marginalis* and *D. Goldieana* to varieties of *D. filix-mas*. For a European who has never seen either of the species growing in its native habitat to take such liberties with American species is to say the least violating the code of international courtesy and ought to stand as a warning to those who still hold to the ancient heresy that Europeans know more about the American flora than we do ourselves.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Schrader's Jour. Bot. **1800**^{2}: 111. 1801.

Osmunda Virginiana L. Sp. Pl. 1064. 1753.

Botrychium gracile Pursh, Fl. Am. Sept. **2**: 656. 1814.

Botrychium anthemoides Presl, Abh. Böhm. Ges. Wiss. **5**: 323. 1847.

BOTRYCHIUM VIRGINIANUM MEXICANUM Hook. & Grev. Bot. Misc. **3**: 222. 1833.

Botrychium brachystachys Kunze, Linnaea, **18**: 305. 1844.

Mexico. Moore referred this to *B. cicutarium*, which he made a subspecies of *B. Virginianum*. The species or variety appears to be quite rare in collections although Mr. Pringle once wrote me that it was quite common in Mexico. It is desirable that it be compared in the field with more northeastern types of the species. The region of Mexico has been widely traversed by Mr. Pringle and others who have brought to light a large number of new species, but they have almost as systematically neglected to collect the old ones, and consequently our knowledge of the distribution of

Mexican plants is still lamentably defective. The whole Mexican region will have to be gone over piecemeal, and collections made that will give some conceptions of the distribution of many of the species of that prolific country. Among them is this Mexican representative of our common rattlesnake fern of which scarcely any specimens exist in American collections.

[The figures on page 49 illustrate four species: *f. 1, 2* = *Botrychium Onondagense*; *f. 3* = *Botrychium Lunaria*; *f. 4, 5* = *Botrychium neglectum*; *f. 6, 7* = *Botrychium tenebrosum.*]

COLUMBIA UNIVERSITY,
25 December 1902.

The Effects of various Chemical Agents upon the Starch-converting Power of Taka Diastase

By Karl F. Kellerman

The importance which the study of enzymes has acquired in the last few years has brought the chemist and physiologist into even closer relationship than that existing before. Furthermore, in studying the general problems of fermentation, both as regards the effects of various enzymes on each other, and in some cases their action in relation to the growth and nutrition of the organism containing them, it has seemed to the writer that as a foundation for accurate work a knowledge of the effects of physical and chemical conditions upon the enzymes is absolutely necessary.

For certain diastases the effects of various physical conditions have been rather carefully worked out, but results relative to the action of chemical agents upon these diastases seem more or less meager and scattered. It has been attempted to study in a systematic way the effect of a considerable number of chemical agents upon diastatic action, and the results of the work are given in this paper.

Taka diastase was chiefly used as the subject of the following experiments, and is here reported upon in detail, on account of its uniformly rapid action and its great keeping qualities. However, most of the work has been repeated, using malt diastase instead of taka, and occasional references will be made to the former.

This taka diastase is the Japanese Saké ferment, prepared from the fungus *Eurotium Oryzae*, and now sold commercially for treatment of amylaceous dyspepsia. This enzyme is a little less sensitive to the presence of foreign substances, and its action, though at first more rapid, is not so complete as that of malt diastase.* That is, there is a greater percentage of starch not converted in the case of taka diastase, even after long-continued action, although the conversion of the other portion of the starch is much more rapid.

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* Stone & Wright, Journal of the American Chemical Society, **20**: 167, 681.

Some rather interesting results were obtained in a preliminary series of experiments. It was found that, the amounts of starch and diastase being constant, the converting power of the enzyme became more and more rapid with the concentration of the solution of starch, or starch paste. The solutions of starch varied from 3 per cent., which is rather viscous, to 0.5 per cent., which is very watery. For determination of the sugar present, all were diluted to 0.5 per cent. to make the physical conditions exactly the same; they were then heated rapidly in an autoclave to 110° C., to destroy the enzyme, and finally the relative amounts of sugar in the different bottles were determined volumetrically by means of Fehling's copper-alkaline-tartrate solution. In each determination, 2 c.c. of the freshly mixed standard was used, diluted to one half concentration, and the solution in question was added drop by drop to the boiling copper solution until the copper was completely precipitated. The end reaction was tested with potassium ferrocyanide in the presence of acetic acid. The relative amounts of sugar in the different solutions can be very accurately determined in this way, the amount of sugar in each bottle varying inversely as the amount of the solution necessary to cause complete precipitation.

Table I shows in detail the variations in speed of starch transformation due to dilution. The ordinates represent the number of cubic centimeters necessary to reduce 2 c.c. of Fehling's solution, and the first four abscissae represent the four different per cents. of starch experimented with. Thus the line starting at the seventh ordinate and 3 per cent. abscissa shows that 7 c.c. of the 3 per cent. starch solution were necessary to reduce 2 c.c. of Fehling's solution; of the 1.5 per cent. starch solution, 8.8 c.c. were necessary, etc.

As Duclaux * has carefully worked out, the conversion of starch into sugar is most rapid soon after action begins, and decreases slowly at first, then more and more rapidly until most of the starch is converted and action ceases.

The last six abscissae in Table I show my results. Here the abscissae represent the number of hours the enzyme was allowed to act before determination.

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* Duclaux, Annales de l'Institut Pasteur, 12: 96.

The effect of increasing the amount of diastase, the starch solution remaining constant, is to increase the rapidity of transformation, though not in proportion to the increase in the amount of enzyme. This is shown in Table I, in the three series that were allowed to act seven, five and three hours respectively. Here the abscissae represent the amounts of a 0.25 per cent. solution of taka diastase used in each case.

In the following experiments * the different chemical agents were prepared each in 100 c.c. of a sterilized 1 per cent. potato starch solution, and placed in thoroughly sterilized and well-stoppered bottles. Usually seven different substances, each with four different concentrations, were tested at the same time. These, together with four to six check bottles, containing 100 c.c. of pure starch solution — to make certain the relative determination of the effects of the various compounds — constitutes a series.

To each bottle of such a series was added 2 c.c. of a 0.25 per cent. solution of taka diastase. All were then placed in a thermostat and kept at 43° C. for about twelve hours. The thermostat was light-proof, and therefore precluded any inaccuracy due to the breaking down of the enzyme by light, or its acceleration caused by the action of light filtered through glass.† After incubation the entire series was placed in an autoclave and heated rapidly to 110° C. This temperature effectually destroys the diastase and any zymogen that might be present, as a preliminary experiment clearly showed.

Care in handling and setting up a series, and sterilization of everything used avoided any inaccuracy due to bacterial action, as indicated by numerous checks.

The relative amounts of sugar in the different bottles were determined volumetrically against 2 c.c. of Fehling's solution, as before. Whenever the chemical agent present interfered with accurate determinations, either by hydrolyzing the starch or by interfering with the reaction of Fehling's solution, the agent was removed or so changed as to be innocuous before heating to destroy the enzyme. Thus acids were neutralized, the copper salts precipitated out as hydroxides, etc.

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* In all cases in these experiments Eimer & Amend's C. P. materials were used

† J. R. Green, Transactions Royal Society, 188, B: 167.

The transformation was allowed to proceed until the check solutions were a little more than half converted into sugar; this corresponds to about the fourth ordinate in the tables.

The chemical agents used are given in fractions of the normal. The normal solution was made by dissolving as many grams of the salt as correspond to its molecular weight in less than one liter of the sterile 1 per cent. starch paste, and the solution then made up to exactly 1,000 c.c. by the addition of the starch paste.

The chemical agents experimented with fall naturally into four classes—the mineral acids and organic acids, the salts of these acids, the alkalies, and the metals.

It will not be attempted to give a complete summation of literature, but such will be cited as seem to bear directly on the subject.

It has been noted by Baranetsky,* Chittenden & Griswold,† and Effront ‡ that strong solutions of mineral acids destroy diastase and weak ones accelerate its action. Cohnheim § records no effect for moderate concentrations of HCl, and Langley & Eves ‖ report that "the slightest trace" (0.015 per cent., about $n/240$) of HCl is very injurious.

Table II shows the results of my work. In this table, as in all following, the abscissae represent the strengths of the chemical agents and the ordinates represent the amount of the solution tested necessary to reduce 2 c.c. of Fehling's solution. "Trace" means that so slight an amount of sugar was present that over 15 c.c. of the solution would be necessary to reduce the Fehling's solution.

At a concentration of $n/10$ all the acids completely checked enzymetic action. At $n/100$ chromic acid gave complete inhibition; the other mineral acids allowed a slight action at $n/100$ and gave a marked acceleration at a dilution of $n/1000$. Sulphuric acid gave the most marked results, the amount of sugar produced being almost double that of the check. Chromic acid still gave a slight inhibition. At a dilution of *n*/10,000 there was a slight acceleration with hydrochloric and nitric acids, and none with the others. Malt diastase requires a *n*/500 dilution before any starch is converted, and at *n*/1,000 requires nearly 12 c.c. to reduce the 2 c.c. of Fehling's solution. Acceleration does not set in until a dilution of nearly *n*/5,000 is reached.

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* Baranetsky, Die Starkeumbildenden Fermente in den Pflanzen. (Leipzig, 1876.)

† Chittenden & Griswold, American Chemical Journal, **3**: 205.

‡ Effront, Comptes Rendus, **115**: 1324.

§ Cohnheim, Archiv für Pathologie, Anatomie und Physiologie (Virchow), **28**: 241.

‖ Langley & Eves, Journal of Physiology, **4**: 18.

Among the organic acids, Detmer * for citric, Krauch † for salicylic, and Kjeldahl ‡ for lactic, butyric, formic, salicylic, acetic and others, record an acceleration for weak dilutions of the acids. §

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* Detmer, Zeitschrift für physiologische Chemie, 7 : 1.

† Krauch, Landwirtschaftliche Versuchstation, 23 : 77.

‡ Kjeldahl, Zeitschrift für das gesammte Brauwesen, 3 : 179. 1880.

§ In this connection, perhaps Dr. Leffmann's paper, "Digestive Ferments with Especial Reference to the Effects of Food Preservatives" (Journal of the Franklin Institute, 147 : 97), should be mentioned.

Dr. Leffmann was working merely to find what antiseptics were injurious to enzymetic action, and records only inhibitory effect. He used only the iodine test to determine the presence of unconverted starch and dextrines, and hence it is impossible to accurately compare his results with mine. It seems, however, that in his experiments with taka diastase, tartaric and citric acids gave a decided inhibition, while in my work, at supposedly corresponding concentrations these acids were almost without effect.

It will be seen on the other hand that he notes no injurious action due to formalin, using 3 c.c. of formalin and, as far as I can gather from his paper, 50 c.c. of 1 per cent. starch. This corresponds to about *n*/3 formalin, which, as will be seen later in my paper, I find to be very injurious indeed. This brings out the fact that the iodine test is entirely inadequate for determinations where formalin is present. If pure starch solution in the presence of formalin is allowed to stand a few hours, it will give a dextrine reaction, and if the action is allowed to continue twelve to twenty-four hours, or if the starch and formalin are boiled together, no starch or dextrine color reaction can be obtained with iodine. Yet if these solutions are treated with NH_4OH to break the formalin down to hexamethyleneamine $(CH_2)_6N_4$, and any excess of ammonia neutralized, iodine will again give the typical starch blue, and Fehling's will give no reaction. Now if the iodine is added immediately upon the addition of formalin to pure starch solution, so that the starch is colored blue, then the formalin does not affect the color even upon standing twenty-four hours ; while if this blue starch solution containing formalin is boiled, it loses its color, even after cooling, and upon the addition of more iodine gives now the red, or so-called erythrodextrine reaction. The action of the formalin is upon the starch, for even if iodine and formalin have been boiled together, the iodine will produce as good a blue as before.

These results hold both for starch paste and fresh starch grains. The latter show no difference under the microscope, even after a treatment with formalin sufficient to preclude their coloring with iodine. It seems to me, therefore, that formalin either has some physical action upon the starch or else forms some unstable compound, comparable to the supposed starch-iodine compound to which is due the blue of the starch test, but being very much more unstable.

By referring to Table II it will be seen that in my work the general effects seem much the same for these acids as for the mineral acids. Malic and acetic acid, however, after giving the usual acceleration near $n/1,000$, gave a marked inhibition as the dilution was carried further. This same peculiarity is shown by sulphuric and citric acids to a very much less extent. Malt diastase shows the same phenomenon. For instance, with acetic acid the acceleration occurs in the region of $n/12,500$ dilution, while $n/62,500$ distinctly retards conversion.

For taka diastase, malic acid did not stop conversion at $n/10$, and at $n/100$ gave a marked acceleration and still greater at $n/1,000$. Then at $n/10,000$ the inhibition was very marked. Acetic acid also did not stop conversion at $n/10$ concentration, but gave no acceleration until a dilution of $n/2,500$ was reached, and at dilutions of $n/12,500$ and $n/62,500$ gave almost as marked inhibition as malic acid.

The work of Gillott * on the inversion of maltose by tartaric, citric and oxalic acids suggested that the apparent increase in the amount of sugar in my experiments with the dilute solutions of these acids might be due to the inversion of the maltose into dextrose. To determine this a $n/10$ solution of each of the acids used was allowed to act on a one-per-cent. solution of C. P. maltose for twenty-four hours at a temperature of 43° C. The solutions were then all neutralized and the coefficients of their reducing power determined and compared with that of the untreated one-per-cent. solution of maltose. There seemed to be very little, if any, difference between them. It would seem, therefore, that the action of the weak acid is a true acceleration, and that the return to the normal action of the ferment at greater dilutions of the acid is due merely to weakening of the stimulus. There remains the chance that the effect of the acids during the breaking up and hydrolysis of the starch into maltose may cause the starch to be changed in part to grape sugar instead of maltose, and thus cause the increased reduction of Fehling's solution.

Among the workers who have dealt with the effects of salts and other bodies upon diastases, Chittenden and Ely † noted the

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* Gillott, Bull. Assoc. Belg. Chim. 13: 80, 119.

† Chittenden & Ely, Journal of Physiology, 3: 327.

increased energy of the enzyme in the presence of one-per-cent. peptone, and also in the presence of sodium chloride, while dibasic sodium phosphate is not favorable. Effront * divided the favorable salts into three groups : salts of aluminum, phosphates and various amides, as asparagin.

From Tables III and V it may be seen that the diastase was much less sensitive to these salts and organic bodies than it was to acids. A normal solution was used as the maximum, instead of one tenth normal. The differences in their effects between sodium, potassium, calcium and magnesium salts of the same acid were greater than the different salts of any one of those bases, which seems here to indicate that the cation is more important than the anion. The calcium and magnesium salts seem more injurious than sodium and potassium, with the exception of the monobasic calcium phosphate, which gives practically no action at *n*/10 concentration, and a marked acceleration at dilutions of *n*/100 and *n*/1,000. Potassium bichromate gave a slight check at *n*/128, and none at *n*/256. Calcium sulphate and magnesium phosphate are so insoluble that they are given on Table III merely in terms of saturation, "*Excess*" standing for a saturated solution at 43°, "*Sat.*" for a saturated solution at 23°. Sodium chloride, potassium nitrate and potassium phosphate gave the greatest acclerations. Malt diastase closely follows the action of the taka diastase and shows no especial point of variation from it in the presence of these chemical agents.

A large number of investigators have tried peptone and asparagin, and all have noted a decided acceleration. Other organic compounds, however, seem to act more as do the salts of the mineral acids ; thay have less marked effects, and are more irregular.

As seen in Table V, sodium acetate and ammonium citrate are the most injurious of those used, giving a marked inhibition at a concentration of *n*/2 ; their injurious action decreases rapidly to some intermediate point, and they accelerate starch conversion at dilutions of *n*/100 and *n*/1,000. Sodium formate and sodium lactate act very slightly either to retard or accelerate transformation. Potassium tartrate and sodium acetate gave the most acceleration of the organic series. Formalin inhibits markedly ; even up to

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* Effront, *l. c.*

n/1,000 nearly halving the amount of sugar. Chloral hydrate is injurious, though a slight acceleration is given at a dilution of *n*/1,000. Peptone accelerates most at 2.5 per cent., and still markedly at $\frac{1}{20}$ per cent. Asparagin accelerates strongly at *n* 20, and still slightly at *n*/1,000.

Many observers note the detrimental action of alkalies on certain diastases. Chittenden & Ely * note a decrease of one third in the amount of sugar due to 1 per cent. of sodium carbonate. Langley & Eves † found 0.0015 per cent. sodium carbonate checks starch transformation, and potassium hydroxide checks more still. They note that the rate of decrease in the effect of weaker concentrations of alkalies is slow compared to acids.

Without exception, in my work the alkalies seemed detrimental; slightly so even up to *n*/10,000 dilution. Sodium, potassium and ammonium seem slightly less injurious than calcium. In no case was there any acceleration in the presence of an alkali. (Compare Table IV.)

The metals are in general injurious. (Compare Table IV.) Iron allowed no action at *n*/10; being more injurious than copper, which did not entirely stop conversion until a *n*/4 concentration was reached. Copper sulphate and copper chloride acted very much alike, both giving a slight acceleration at *n*/10,000. Silver was very detrimental indeed. No conversion took place below *n*/10,000, and only a slight amount at *n*/100,000. Zinc nitrate and barium chloride gave a peculiar curve, similar to that of some of the acids, but at *n*/100 barium chloride just reached the normal, and inhibited at *n*/1,000, while zinc nitrate accelerated transformation at *n*/100 and inhibited action at *n*/1,000.

The work of Clark ‡ on the decrease of toxicity of mercuric chloride by the addition of other chlorides suggested that a similar series of experiments be tried on taka diastase.

In my experiments a *n*/5,420 solution of mercuric chloride was used, and to that varying amounts of calcium chloride were added. The results were very striking, as is shown in Table VI. Here the plain line represents the action of the solution of constant strength of mercuric chloride to which various dilutions of other chlorides were added. The crossed line represents the action of the various dilutions of the chlorides alone.

---

* Chittenden & Ely, *l. c.*

† Langley & Eves, *l. c.*

‡ Clark, Journal of Physical Chemistry, 5: 289.

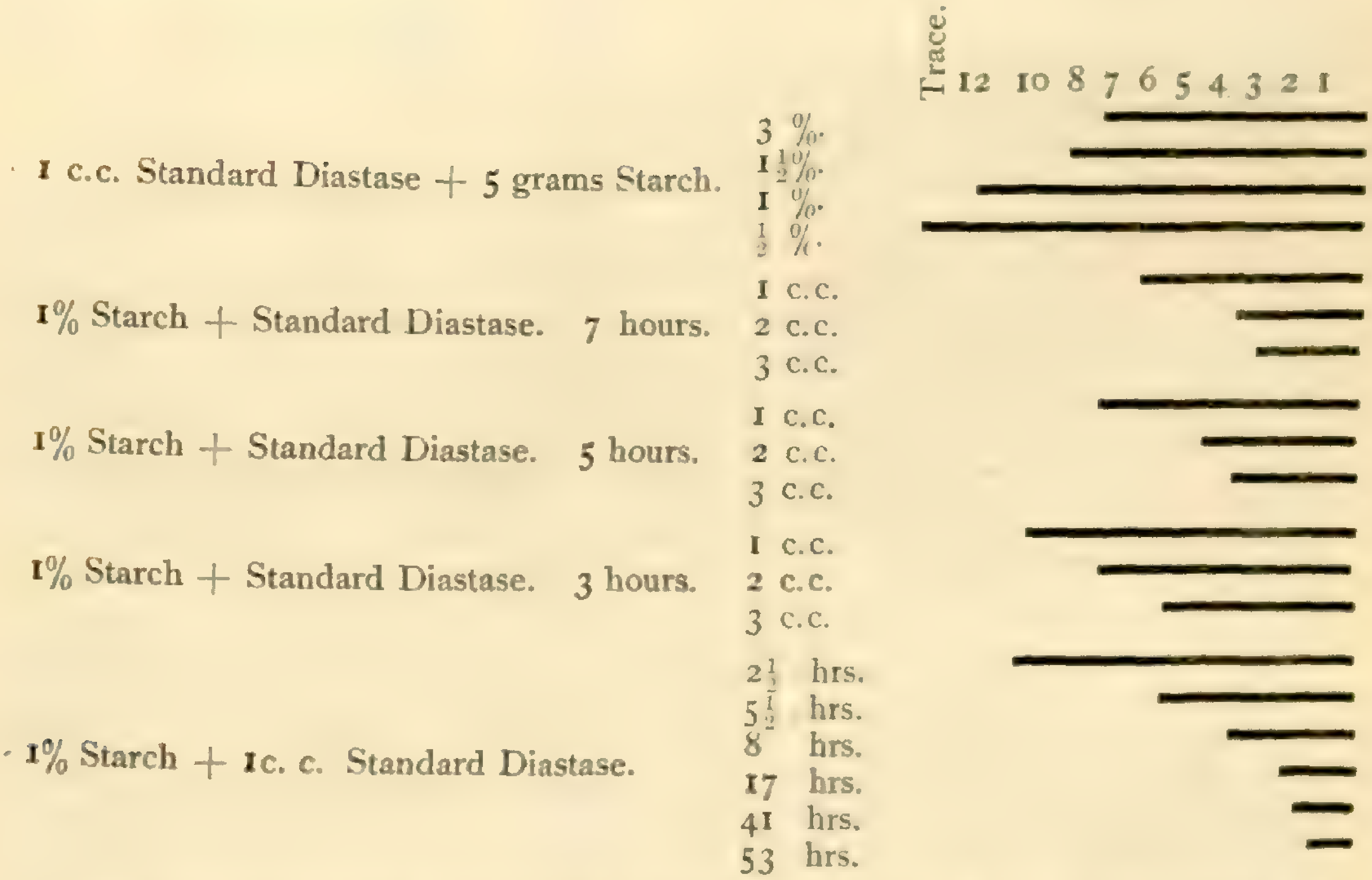
At the strong concentrations of the calcium, the check solutions containing only calcium were only slightly more rich in sugar than the solutions containing the mercury also. From *n*/10 to *n*/1,000, however, while calcium alone gave a slight increase above the normal starch transformation, the solutions containing mercury also were rapidly checked, until at *n*/1,000 dilution of calcium the *n*/5,420 mercuric chloride completely checked starch transformation.

A similar series of experiments was made with barium chloride substituted for calcium, and with as marked results. Then a series was carried through using sodium chloride, with four concentrations of mercuric chloride. Here the amount of sodium chloride was so constantly in excess that the sodium and sodium-mercury lines run fairly near together on the chart. It seems, however, to indicate an increase of injurious effect at the last dilution.

In conclusion I beg leave to acknowledge my indebtedness to Dr. B. M. Duggar, assistant professor of plant physiology, and Professor George F. Atkinson, professor of botany in Cornell University, for constant encouragement and every courtesy and assistance in the prosecution of this work.

TABLE I.

SHOWING EFFECT OF VARIATION OF TIME, CONCENTRATION OF DIASTASE AND CONCENTRATION OF STARCH

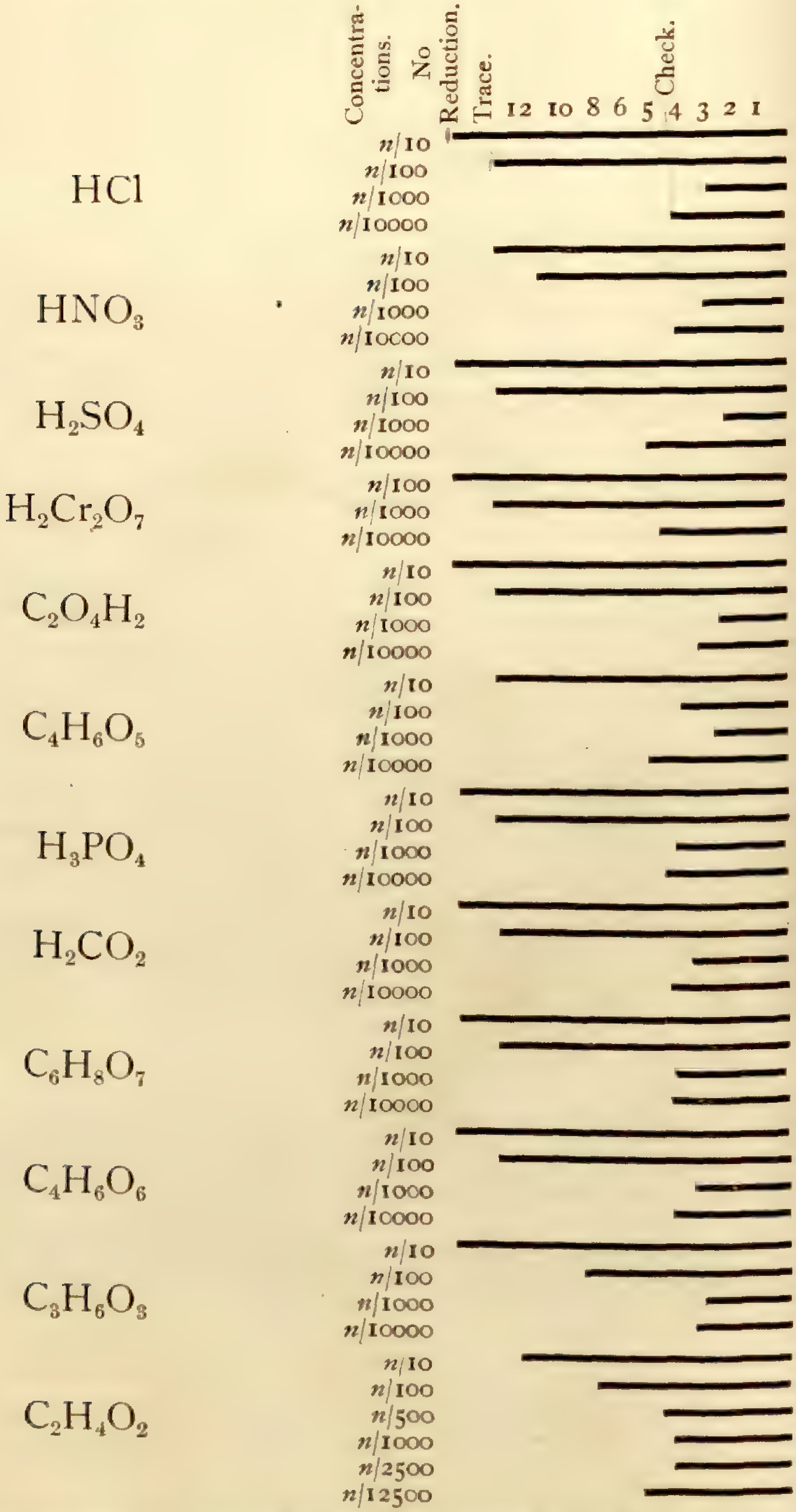


The numbers above the ordinates represent the number of cubic centimeters of the solution tested necessary to completely reduce 2 c.c. of Fehling's solution; therefore the shorter the heavy line, the greater has been the starch transformation in that particular case.

The numbers by the abscissae represent percentage of starch, amount of diastase, and variation of time, respectively.

TABLE II.

SHOWING EFFECTS OF VARIOUS ACIDS



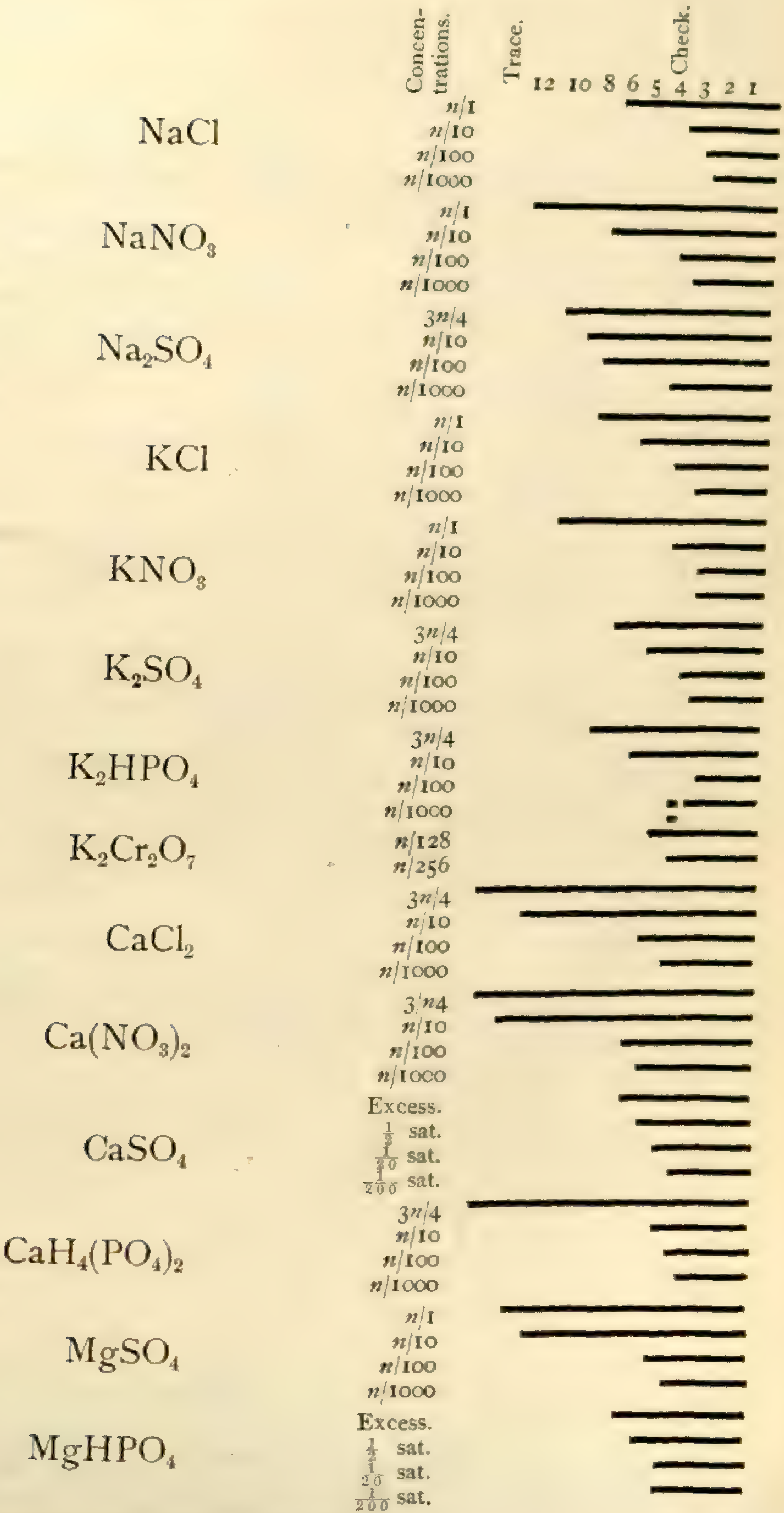
The ordinates represent the number of cubic centimeters of the solution tested necessary to reduce 2 c.c. of Fehling's solution, "Trace" representing an amount of over 15 c.c.

The abscissae represent the fraction of the normal concentration of the chemical agent used.

The check between 4 and 5 represents the number of cubic centimeters of the check solutions, containing only pure starch and diastase, necessary to reduce 2 c.c. Fehling's solution.

TABLE III.

SHOWING EFFECTS OF VARIOUS SALTS



The check in this table is slightly less than 4.

TABLE IV.

SHOWING EFFECTS OF VARIOUS ALKALIES AND METALS

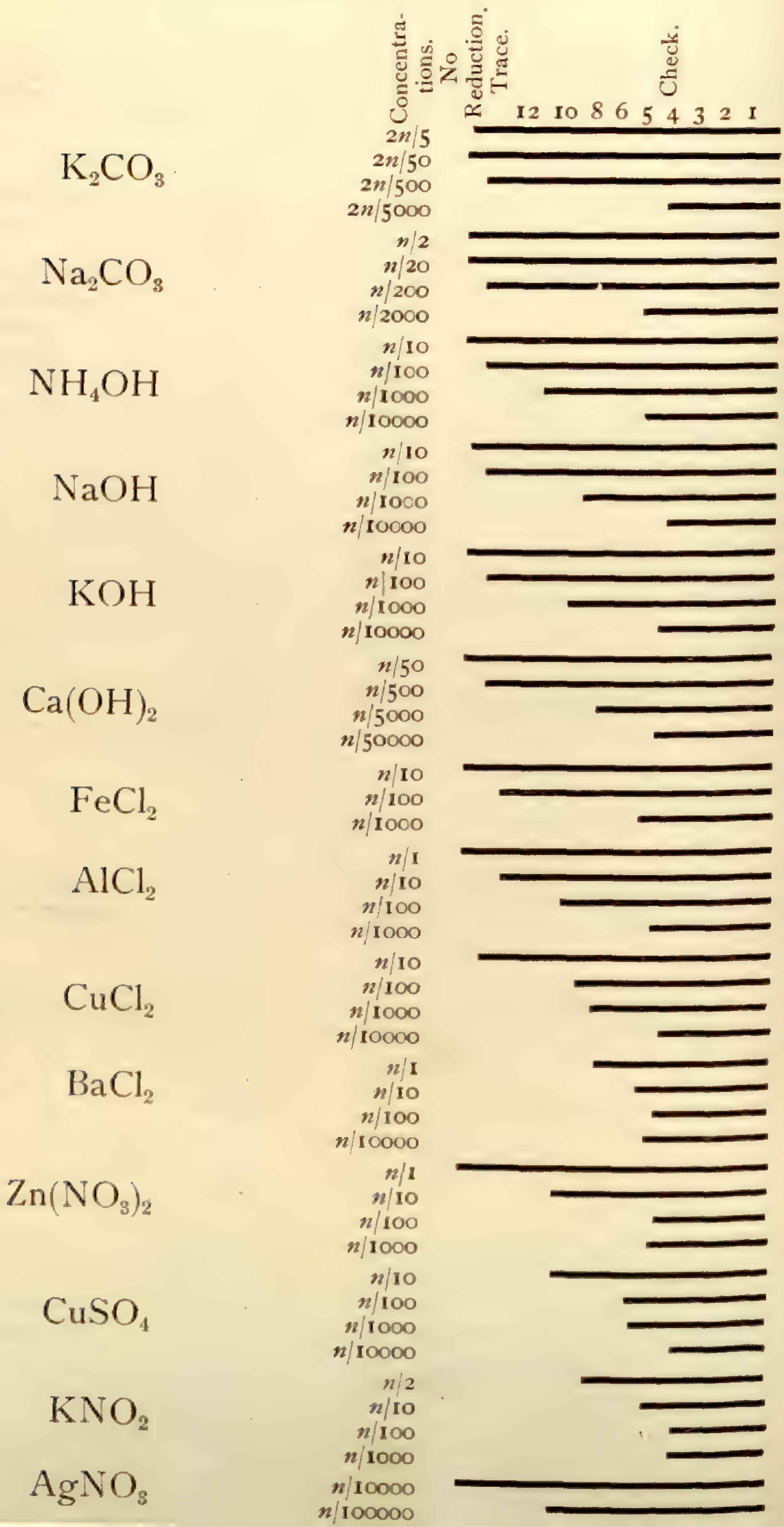


TABLE V.

SHOWING THE EFFECTS OF VARIOUS ORGANIC COMPOUNDS

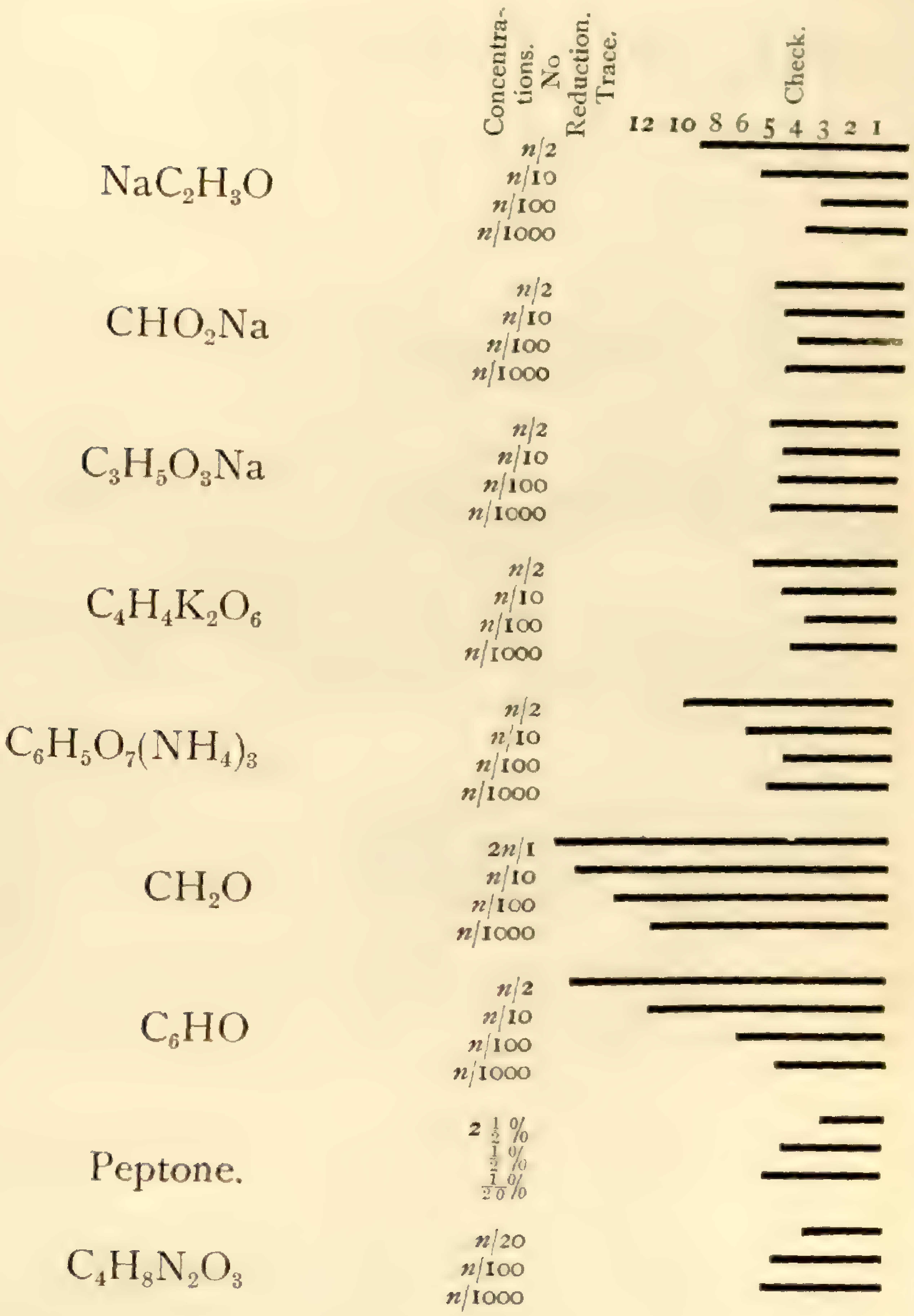
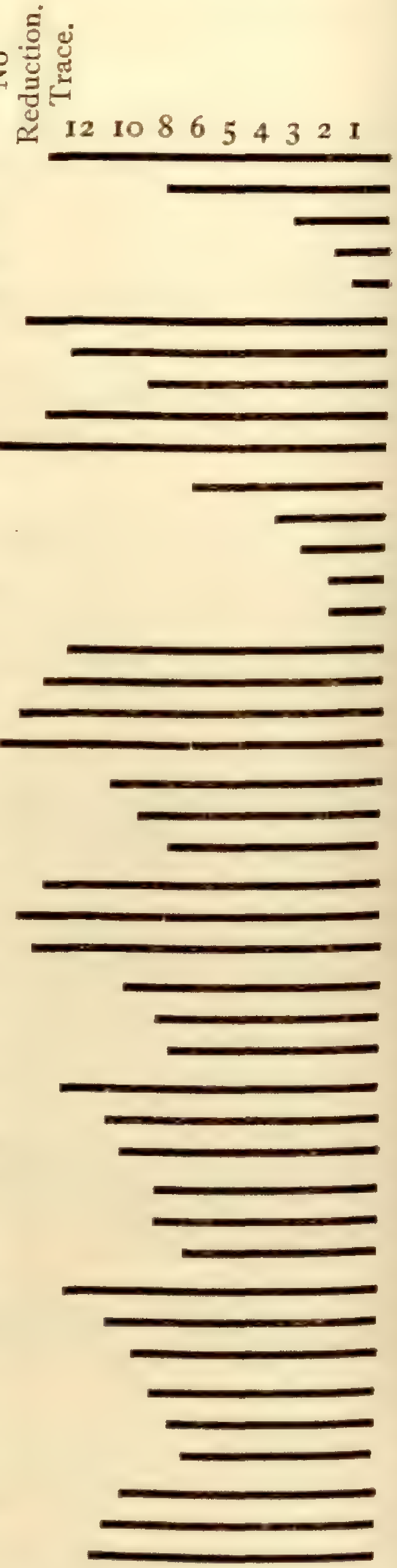


TABLE VI.

SHOWING THE EFFECTS OF ADDING VARIOUS OTHER CHLORIDES TO MERCURIC CHLORIDE

$HgCl_2$ + varying amounts of other chlorides and these other chlorides alone.	Concentration.
$CaCl_2$	n/2
	n/4
	n/10
	n/100
	n/1000
$HgCl_2$ n/5420 + $CaCl_2$	n/2
	n/4
	n/10
	n/100
	n/1000
$BaCl_2$	2n/1
	n/4
	n/10
	n/20
	n/100
$HgCl_2$ n/2710 + $BaCl_2$	2n/1
	n/4
	n/10
	n/20
NaCl	2n/1
	n/1
	n/2
$HgCl_2$ n/2710 + NaCl	2n/1
	n/1
	n/2
NaCl	n/1
	n/2
	n/4
$HgCl_2$ n/5420 + NaCl	n/1
	n/2
	n/4
NaCl	n/2
	n/4
	n/8
$HgCl_2$ n/10840 + NaCl	n/2
	n/4
	n/8
NaCl	n/4
	n/8
	n/16
$HgCl_2$ n/21680 + NaCl	n/4
	n/8
	n/16



The concentration of mercuric chloride remains constant in each experiment, and to this varying concentrations of some other chloride are added.

The difference between the effect of the mercuric chloride + chloride and the check, containing no mercury, shows the effect of these other chlorides on the mercuric chloride.

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1-9. DREPANOLEJEUNEA BIOCELLATA Evans.
10-19. DREPANOLEJEUNEA SUBULATA Steph.

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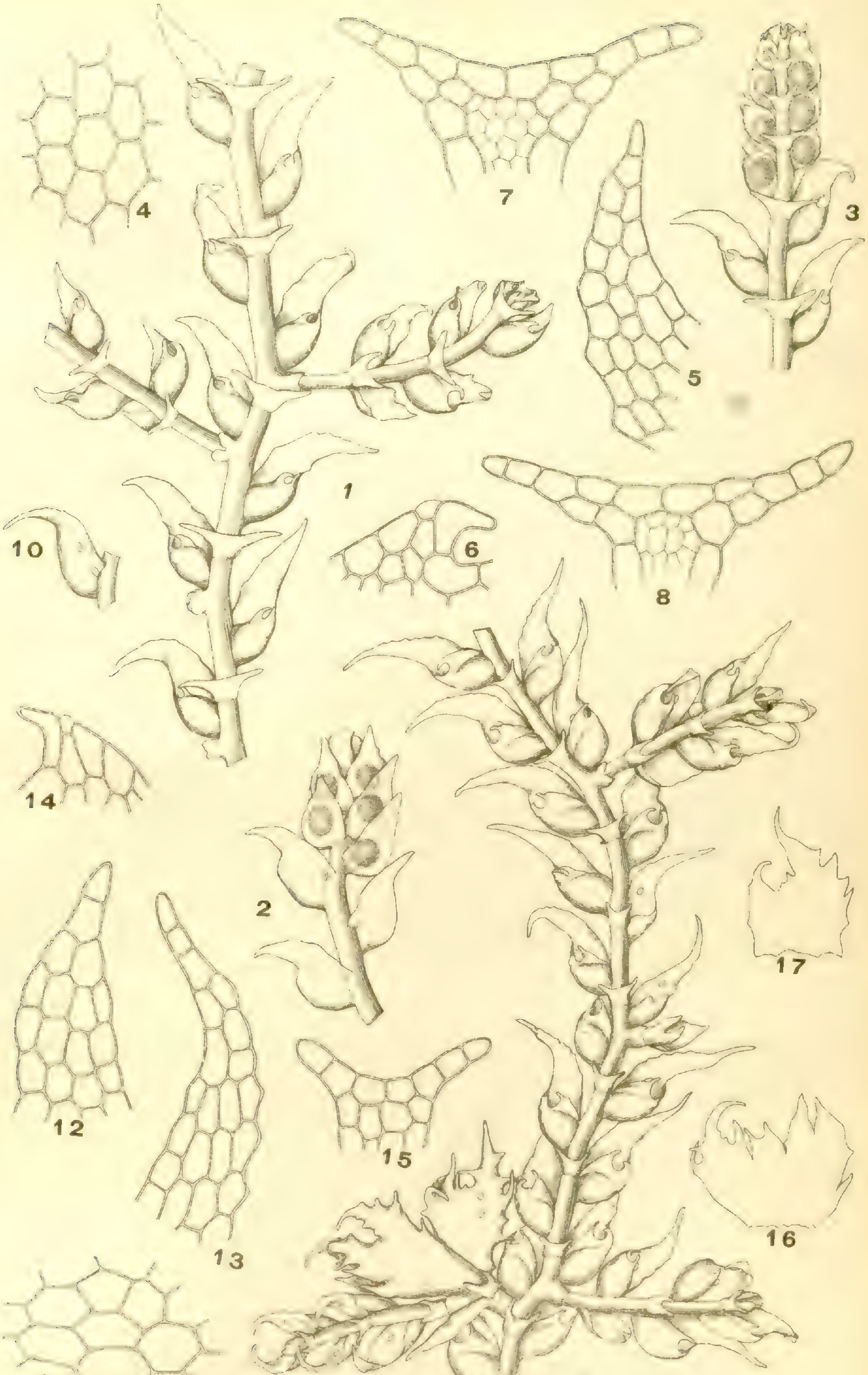
1-13. DREPANOLEJEUNEA CRASSIRETIS Evans.

14-23. DREPANOLEJEUNEA ARAUCARIAE Steph.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1-8. DREPANOLEJEUNEA DISSITIFOLIA Evans.

9-17. DREPANOLEJEUNEA BIDENS (Steph.) Evans.

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1-7. DREPANOLEJEUNEA BISPINULOSA Evans.

8-17. DREPANOLEJEUNEA CRUCIANELLA (Tayl.) Evans.

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DREPANOLEJEUNEA INFUNDIBULATA (Spruce) Evans.

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DREPANOLEJEUNEA INCHOATA (Meissn.) Schiffn.

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Corresponding Secretary,
JOHN K. SMALL, PH.D.,
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BULLETIN

OF THE

TORREY BOTANICAL CLUB

FEBRUARY, 1903

On atavistic Variation in Oenothera cruciata

BY HUGO DE VRIES

After *Oenothera Lamarckiana* had shown itself to be a very proper material for the study of the mutations by which new species suddenly arise from old ones, I was naturally led to investigate whether in other plants similar mutations might not be met with. For it is clear that the phenomena shown by Lamarck's evening primrose are of prevailing interest only if they may be taken as an instance of a general rule. The other species of the same genus were of course the first to receive attention. Most of these showed no signs of being fit for a study along the same lines, while on the other hand one, *Oenothera cruciata*, was found to be inconstant in the very character to which it owes its name. At least the plant which is cultivated under this name in European botanical gardens is variable in this regard.

In proposing to bring the results of my experimental cultures of this plant before the readers of this journal, my aim is principally to direct their attention to any deviations which the species of the above-named genus might show in their native localities. For it is of undoubted interest to the study of mutability to know whether the variability which *Oenothera cruciata* displays with us is also met with in America, in those parts where the plant grows wild. The allied forms such as *O. biennis* and *O. muricata*, should be tested in the same direction. Any deviations from the original types should be carefully observed and if possible perpetuated by seeds. Wherever such deviations are found the question would have to be answered whether the general type of the locality possesses the power of again producing this deviation, and perhaps others too, in succeeding years.

[The preceding number of the BULLETIN, Vol. 30, No. 1, for January, 1903 (30: 1-74, *pl. 1-6*), was issued 4 F 1903.]

Oenothera cruciata Nutt. or *Onagra cruciata* (Nutt.) Small, as it is also called, has been described and figured in Britton and Brown's "Illustrated Flora of the Northern United States, Canada and the British Possessions" (**2**: 485. 1897). It is a rare plant, found wild from Vermont to New York and Massachusetts, and ascends to 2,000 feet in the Adirondacks. It is described as being annual and flowering from August to October. It may readily be recognized, even without flowers, by the narrowly oblong or oblanceolate leaves and the purple color of the nerves and the stem. The flowers are as small as those of *O. muricata*, but the spikes are much more slender and the fruits are less broad. In all these characters the European plants correspond exactly with the description given by Britton and Brown. The petals of the American type are linear instead of being broad and obcordate as in the allied species.

As yet I have not had an opportunity to cultivate the original wild species, but I hope to be able to do so next year, as I have obtained seeds from the Adirondacks through the kindness of Dr. D. T. MacDougal, of New York, and Dr. B. L. Robinson, of Cambridge, Mass.*

Dr. MacDougal had also the kindness to ask Dr. Britton about an eventual variability of the petals, but the celebrated author of the Illustrated Flora informed him that *Oenothera cruciata does not make broad petals* in America.

This is the essential point. For in all the cultures I have as yet been able to make from seeds of this species, sent to me from different botanical gardens in Europe, I found the form of the petals to be varying in a high degree, so as to reach, in many individuals, the same outline as is presented by the petals of the allied species, *O. biennis*, *O. muricata* and others.

For this reason, I presume that our plants are not the typical *O. cruciata* of Nuttall, but a variety, which perhaps has been produced from it in Europe. Therefore I have called my plants *O. cruciata varia*, merely in order to distinguish them from the pure species. How this variety may have originated of course I do not know. Two possibilities present themselves. The one is by mu-

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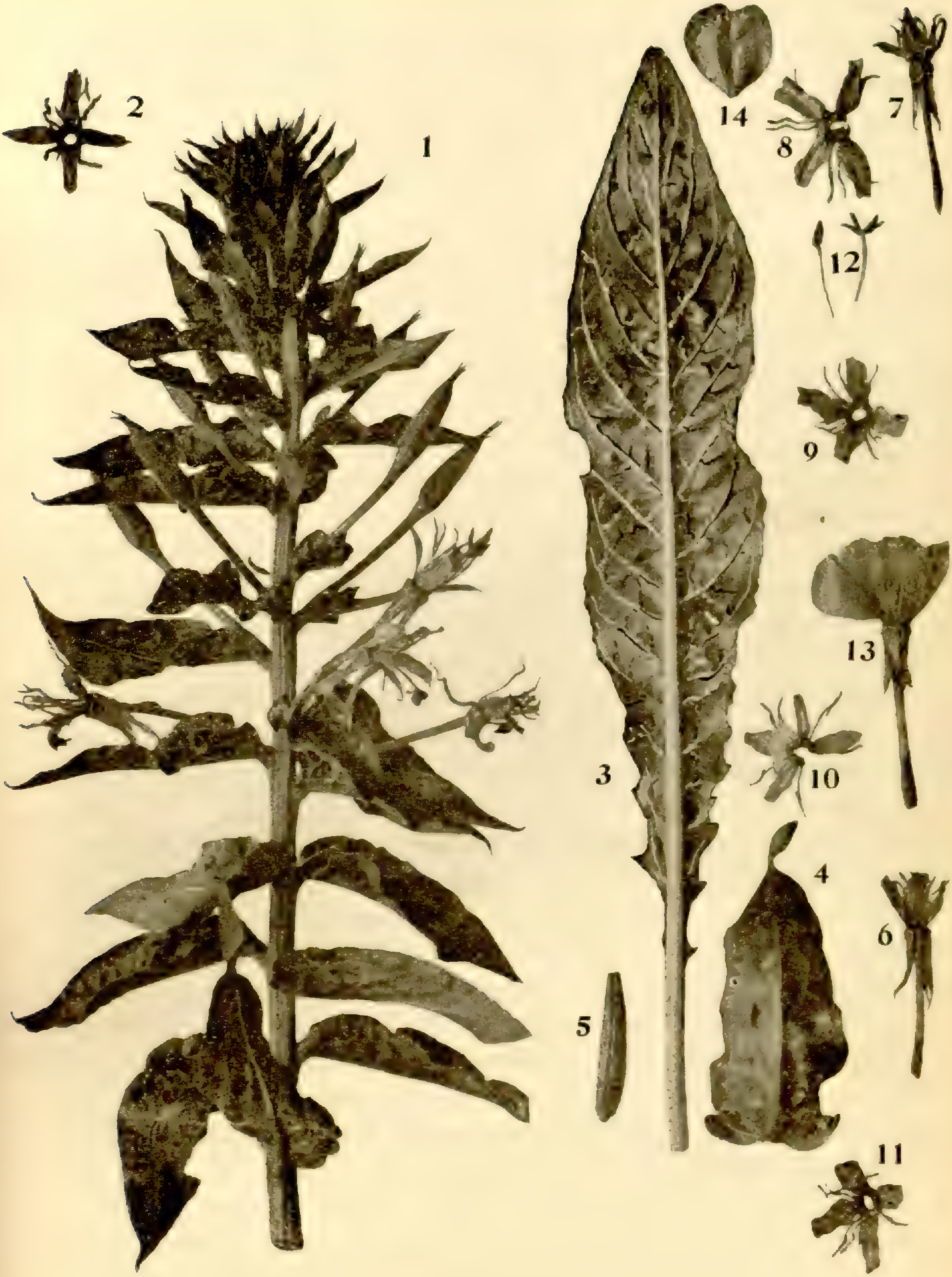
* Seeds from different localities would be always very welcome to me, as the plant may be in a mutable state in some districts, while it is not so in others.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Figs. 1, 2. *Oenothera cruciata* Nutt.
Figs. 3–14. *Oenothera cruciata varia* De Vries.

tation, in the same way as many of our ordinary varieties of garden plants have been produced, the other is by crossing, which is perhaps a still more common source of new garden varieties.

Both possibilities seem to me to be of some interest, since they bear directly on the great question of the internal causes of inconstancy in general. For in my variety the petals do not vary according to Quetelet's law, about a mean, which lies somewhere between the obcordate and the linear form, producing petals of which the majority do not essentially differ from this mean, whilst the extremes are very rare. Quite on the contrary, the obcordate and the linear petals seem to be two alternating types only united by rare intermediate steps.

In case my variety originated by a mutation, we would therefore have an imperfect one, producing the new type only in part of the individuals and remaining true or returning to the pure form of *Oenothera cruciata* in the others. In many points this case would be analogous to that of *Oenothera scintillans*, which originated in my garden from *O. Lamarckiana*, but which, though artificially pollinated with its own pollen, returns in each generation in often a relatively large part of the individuals to the original type.

In case my variety originated by a cross, it should first be remarked that the supposed hybrid is not intermediate between *O. cruciata* and some allied species, but that it has, as far as I can judge, all the characters of the former, the constancy in the form of the petals excepted. I have endeavored to show in my "Mutations-theorie" (Part II., p. 100) that *O. muricata* is probably the only species which could have given such a hybrid with the *O. cruciata.* Now it is clear that having once obtained seeds from the original and constant *O. cruciata*, I possess the materials to bring about this crossing and also those with other allied species, and to try whether it will be possible to get an inconstant hybrid in this way. I propose to do so, but from what I know of my *O. cruciata varia* and of the hybrids I have made of it with more than one other species, it is very improbable that the hybrid *O. cruciata* × *O. muricata* will be as a rule inconstant. It is far more probable that it will exhibit the dominant character, which must be the broad petals, and either give a constant progeny with this feature or split up according to Mendel's laws. I take the broad petals to be phylogenetically older than the linear ones, because they are the rule in the whole genus. But some authors suppose that from time to time there arise exceptions to the ordinary laws governing hybrids, and that such exceptions might be the source of many inconstant varieties and even of inconstancy in general. In this case the chance of getting such an exception by crossing would scarcely be greater than that of getting a mutation from the pure type.

However slight these chances may be, I propose to try both ways and to see whether it would be possible to repeat the as yet doubtful and unknown original production of my *O. cruciata varia.* For there are not a great many cases in which the starting-points are to be had in so pure and so thoroughly controlled a state as in this instance. As to the question of the rule of the constancy of *O. cruciata* under cultivation, and of the hybrids, I hope to solve this in some years; but as to the chances of getting exceptions, it is evident that these are only small and that it would be preferable if the same experiments were made by a number of investigators.

The aim of such experiments would be to repeat artificially the production of *O. cruciata varia* and by this means to throw some light on its origin in particular and on the origin of inconstant varieties in general. With a view to the possible repetition of this cross I will now give a description of the inheritance of the broad and linear petals in this variety. In so doing I limit myself to the detailed exposition of a single experiment carried on with the descendants of one original specimen of my variety.

In the year 1897 this plant was raised from seed obtained in the usual way of exchange between botanical gardens. I obtained but a single specimen, which bore all the characteristics of the typical *O. cruciata.* The spike, before the opening of the flowers, was placed in a bag of prepared parchment paper to prevent any visits from bees. The anthers touch the stigmas when opening, and the flowers fertilize themselves without any aid. In the same way I always took care to collect each year purely pollinated seeds only.

This original plant bore but a few seeds, from which during the next year I obtained only sixteen flowering individuals. But this number was sufficient to show the whole range of the variability of the race. Nine plants bore typical cruciate flowers with linear petals, two specimens had broad obcordate petals like those of *O. muricata*, and the five remaining had an intermediate breadth, varying in all degrees between these two extremes. Even on the same spike the petals of the different flowers were in this regard unlike each other, and sometimes of the four petals of one flower some were narrow and others broad. I also found petals large on one side of the median nerve and small on the other side.

I obtained pure seed of some of the narrow-petalled ones and of some of the intermediate specimens, separately for each plant, and the next year (1899) had four groups flowering. Two of them from two typically cruciate mothers repeated this type only, each group in thirty plants. One group, also from a cruciate mother, produced twenty-two typical and eight atavistic individuals, meaning thereby those with broad obcordate petals. Intermediate types were wanting. So it was with the fourth group, the children of an intermediate mother, of which only four were purely cruciate, the remaining fifty-eight being atavistic.

Afterwards I continued these four strains, sowing from the two last named in 1900, from the first named in 1901. The atavistic mothers gave only children which were in this regard like them. The purely cruciate strains on the other hand continued to produce atavistic and intermediate types, and these last were also inconstant as far as I observed them.

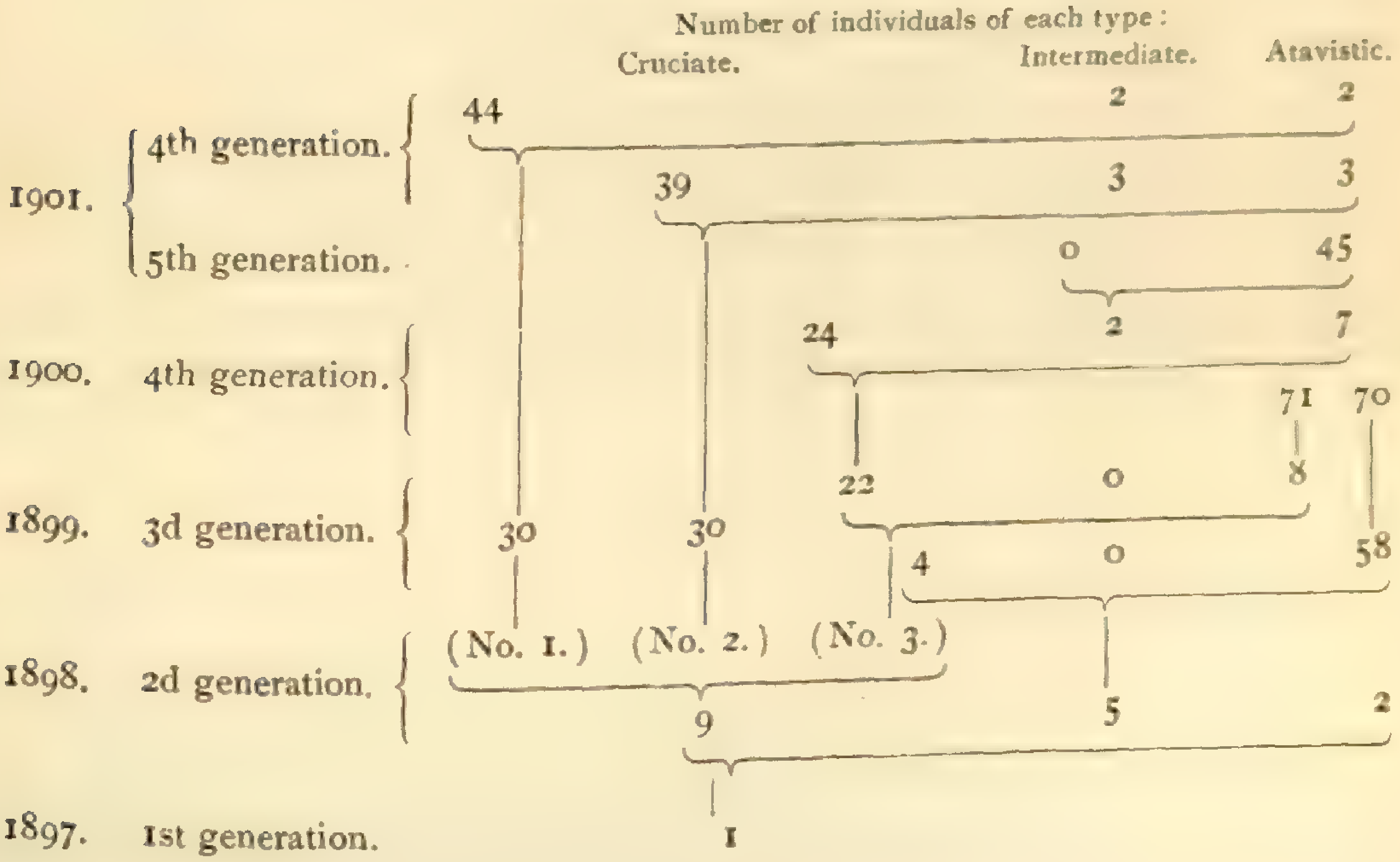
Taking the five generations together, I had 232 children from cruciate mothers, 103 from intermediate and 141 from atavistic parents. The first group consisted of 85 per cent. cruciate, 5 per cent. intermediate and 10 per cent. atavistic individuals. The second, of 4 per cent. cruciate, no intermediate and 96 per cent. atavistic specimens. The third was nearly constant, all individuals bearing the broad obcordate petals.

I say nearly constant, for among those atavists I observed some cases of bud-variation, by which they returned to the cruciate type. This rare phenomenon occasionally presents itself without apparent reason, but it may be induced to appear oftener in the following manner. Around the main stem the plants produce a circle of smaller stems growing upwards from the axils of the root leaves. In my cultures these side-stems do not ordinarily become tall enough to bear flowers. But by cutting out the main stem at an early period I could induce the others to a more vigorous growth. I repeatedly made this experiment; but will only cite here observations made on a single plant in the summer of 1901, grown from seed of a purely cruciate parent. It made six side-stems, out of which three bore only atavistic or broad-petalled flowers. The three other stems likewise produced obcordate petals, but not exclusively, bearing on one side of the spike flowers with the narrow and variable petals of the above-named intermediate types.

Such cases prove that the atavistic individuals are not, or at least are not always, so constant as could be deduced from the figures above given. Analogous instances of sectorial variation, one sector of the spike bearing other flowers than the remaining sectors, were from time to time observed on atavistic individuals and also on intermediate ones, the sport giving flowers with obcordate petals. As yet I have found no such sports on plants of the purely cruciate type nor purely cruciate flowers on those of the two other types. But I have no doubt that this is only due to the small extent of my cultures.

PEDIGREE OF

Oenothera cruciata varia


Number of individuals of each type:
Cruciate.
Intermediate.
Atavistic.
1901.
4th generation.
5th generation.
1900.
4th generation.
1899.
3d generation.
1898.
2d generation.
1897.
1st generation.
44
2
2
39
3
3
0
45
24
2
7
71
70
22
0
8
30
30
4
0
58
(No. 1.)
(No. 2.)
(No. 3.)
9
5
2
1

I give, above, the description of my whole race in the form of a pedigree, omitting the sectorial and bud-variations, again reminding the reader that in every case the seed-bearing plants were fertilized only with their own pollen after enclosure in bags of prepared parchment-paper.

Though the figures of this experiment are but small, they seem to be sufficient to prove the presence of a very curious case of variability, the alternation between the typical cruciate flowers of the species and the atavistic petals of the group to which the species belongs, and to justify the provisional name chosen for my race: *Oenothera* or *Onagra cruciata varia.*

AMSTERDAM.

Nova Ascomycetum Genera Speciesque *

FREDERIC E. CLEMENTS

Chaetosphaeria Thalictri

Peritheciis solitariis, vel laxe gregariis, superficialibus, globosis, ostiolatis, distincte papillato-depressis, pilis flexuosis brunneis 100 × 3 μ dense setulosis, 200–300 μ diam.; ascis octosporis, clavatis, paraphysatis, iodo caerulescentibus, 90–100 × 10 μ; sporis distichis, fuscis, fusiformibus, 3–5-septatis, saepius 4-septatis et loculo secundo turgido, ad septa leniter constrictis, 30–35 × 4–5 μ; pycnidiis globosis, glabris, 200–300 μ, conidiis hyalinis, continuis, oblongis, 6–8 × 1½ μ.

In caulibus mortuis *Thalictri sparsiflori*, Minnehaha, Colorado, Augusto, 1900.

Pleosphaeria Lithospermi

Peritheciis sparsis, superficialibus, submembranaceis, globosis, deinde collabentibus, minute papillatis, extus pilis simplicibus, septatis, brunneis 150 × 4–5 μ obsitis, sed vertice nudis, 250 μ diam.; ascis octosporis, late clavato-oblongis, paraphysatis, iodo non caerulescentibus, 120–140 × 20–25 μ; sporis monostichis vel distichis, oblongo-ellipticis, luteo-brunneis, 7-septatis, loculis 2–3-septatis, ad septum medium valde constrictis, ad alia leniter constrictis, 25–30 × 14–15 μ.

Ad caules mortuos *Lithospermi parviflori*, 'Cross Ruxton, Minnehaha, Septembri, 1900.

Tichosporium (Sacc.)

Perithecia sparsa vel gregaria, superficialia vel basi immersa, sphaeroidea vel ovata, ostiolo papillari vel inconspicuo, coriacea vel carbonacea, atra, glabra. Asci cylindracei vel clavati, typice 8-spori. Sporidia elliptica vel oblongata, murali-divisa, hyalina. Paraphyses graciles aut parum notabiles.

Tichosporium Edwiniae

Peritheciis copiosis, superficialibus, ad basim innatis, submembranaceis, depresso-globosis, deinde cupulate collabentibus, glabris, vix ostiolatis vel vere astomatis, rima apicali dehiscentibus, nigris, 175–300 μ diam.; ascis octosporis, late oblongis, membrana crassa, vix vel non caerulescentibus, 60 × 12–14 μ; sporis oblique monostichis, oblongo-ovatis, hyalinis, 4–6-septatis, saepius 5-septatis, loculis, terminalibus exceptis, 1-divisis, ad septa distincte constrictis, 20–22 × 8–10 μ.

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* Species hic inventae in statu vivo descriptae, et in pigmento aqua diluto pinctae sunt. Colorum nomina Saccardii Chromotaxiae sunt. Typi omnium specierum generumque in herbario meo conservantur.

Ad ramos decorticatos *Edwiniae Americanae*, Minnehaha, Septembri, 1900. *Tichosporium* est *Teichosporella* Sacc., sectio *Teichosporae* (*Strickeriae*). *Teichosporella* verbum hybridum est, itaque ad *Tichosporium* corrigenda.

Mycosphaerium lineatum *

Peritheciis gregariis, in lineis longis vel maculis elongatis elevatis nigris dense dispositis, innatis, epidermide tectis, deinde suberumpentibus, conico-sphaericis, vix vel non papillatis, glabris, subiculo sparso brunneo insidentibus, minutis, 100 μ diam.; ascis octosporis, clavatis, brevibus, aparaphysatis, iodo non caerulescentibus, 60 × 12–15 μ; sporis irregulariter dispositis, ovato-oblongatis, uniseptatis, hyalinis, levibus, intus minute granulosis, 16 × 6–8 μ: nomen propter perithecia lineatim disposita.

Ad caules emortuos *Pedicularis procerae*, Dark Cañon, Julio, 1900. Est *M. trichophila* (Karst.) nuda; *M. Tassianae* (DeNot.) Johan. affinis.

Phorcys minutus

Peritheciis solitariis, copiosis, raro subgregariis, primitus tectis, deinde epidermidem nigricantem pertusis, submembranaceis, depresso-globosis, ostiolo depresso, rugulosis, atro-brunneis, minutis, 85–150 μ diam.; ascis 6–8-sporis, irregulariter clavatis, brevibus, ad basim attenuatis, 80 × 16–18 μ; paraphysibus linearibus, paucis; sporis monostichis, sursum distichis, oblongo-ellipticis, uniseptatis, ad septum constrictis, levibus, brunneis, biguttatis, 13–16 × 6–7 μ: nomen propter perithecia minuta.

Ad folia vetusta exsiccataque *Yuccae glaucae*, 'Cross Ruxton, Septembri, 1900.

Metasphaeria Opulastri

Peritheciis sparsis, erumpentibus, nudis, globosis, vix ostiolatis, brunneis, 200–300 μ; ascis octosporis, clavatis, iodo non caerulescentibus, 60–75 × 10 μ; paraphysibus clavulatis, hyalinis, 2–3 μ lat. ad apicem; sporis fusiformibus, acutis, plerumque 3-septatis, rectis vel curvulis, hyalinis, 22–25 × 3–4 μ.

Ad ramulos vetustos *Opulastri monogynae*, Minnehaha, Septembri, 1900.

---

* Pro *Mycosphaerella* Johan., nomine hybrido.

Leptosphaeria Castilleiae

Peritheciis copiosis, numerosis, primitus tectis, deinde erumpenti-superficialibus, globosis, ostiolatis, vix conicis vel papillatis, glabris, 150–200 μ; ascis octosporis, oblongis, paraphysatis, iodo non caerulescentibus, 80–100 × 8–10 μ; sporis distichis, fusiformibus, 3–4-septatis, curvulis, raro rectis, acutis vel obtusis, ad septa leniter vel non constrictis, fusco-flavis, 40–50 × 4 μ; pycnidiis globosis, 100–150 μ, basidiis 10 × 1 μ, conidiis oblongis, hyalinis, 6–8 × 2 μ.

Ad caules emortuos *Castilleiae pallidae*, Ruxton Park, Septembri, 1900. A *L. Ogilviense* (B. & Br.) Ces. differt sporis 3–4-septatis, enucleatis, peritheciis erumpentibus, non papillatis; a *L. concinna* Ell. & Ev. peritheciis epapillatis, erumpentibus, sporis majoribus.

Pleospora Edwiniae

Peritheciis sparsis, tectis, deinde cortice dejecto superficialibus, depresso-globosis, ostiolatis, vix vel non papillatis, magnis, 500–600 μ; ascis 4–6-sporis, clavatis, iodo non vel indistincte caerulescentibus, 100–120 × 15 μ; paraphysibus numerosis, linearibus, ascos valde superantibus; sporis recte monostichis, late ellipticis, 4-, saepius 5-septatis, uno septo verticale in omne loculo, ultimis saepe exceptis, ad septa leviter constrictis, ad secundum semper valde constrictis, fusco-brunneis, 20–25 × 12–14 μ.

Ad ramos siccatos *Edwiniae Americanae*, Sugar Loaf, Septembri, 1900.

Pleospora sepulta

Peritheciis subcopiosis, sepultis sub epidermide rotundato-elevata vel hysteroidea, globosis, vix ostiolatis, carbonaceis, glabris, magnis, 400–500 μ; ascis 6–8-sporis, clavato-cylindraceis, iodo non caerulescentibus, paraphysibus linearibus, simplicibus, valde torulosis, apice 4 μ lat.; sporis oblongo-fusiformibus, oblique monostichis, utrinque attenuato-acutis, 8–11-, plerumque 9–10-septatis, septo verticale uno, nonnunquam duobus, ad medium constrictis, in aetate disintegratis, flavis dein brunneis, 30–45 × 10–14 μ.

Ad ramos ignotos vetustos decorticatosque, Minnehaha, Septembri, 1900.

Psilothecium

Apothecia superficialia, sessilia, ceraceo-coriacea, cupulato-hemisphaerica, nuda, nigra, minuta; epithecium nullum vel obsolescens, paraphyses lineares, simplices, hyalinae; hymenium laeticolore; hypothecium plectenchymaticum, crassum, pallide fuscum;

excipulum carbonaceum, crassum, glabrum vel tuberculatum, brunneo-nigrum, margine libero incurvo. Asci octospori, clavati, iodo non tincti. Sporae continuae, hyalinae, ellipticae, leves. Nomen propter epithecium obsoletum, *ψιλός*, nudus, *θηκεῖον, τό*, hymenium. *Patinellae* affinis, sed differt paraphysibus simplicibus, epithecio nullo hymenioque laeticolore.

Psilothecium incurvum

Apotheciis superficialibus, sessilibus, gregariis, ceraceo-coriaceis, oblato-hemisphaericis, 400–700 μ lat., 300–400 μ alt.; hymenio pallide brunneo vel isabellino, 125 μ alt., paraphysibus linearibus, simplicibus, superne vix vel haud incrassatis, hyalinis, 2 μ lat.; hypothecio plectenchymatico, pallide isabellino 125 μ alt.; excipulo isabellino, sub micr. nigro-carbonaceo, cellulis 6–8 μ diam. extus crebro minuteque tuberculatis, infra 50 μ cr., margine libero, incurvo, 25 μ cr.; ascis octosporis, clavatis, stipitatis, iodo non tinctis, 70–80 × 10 μ: sporis recte vel oblique monostichis, ellipticis, hyalinis, levibus, 8–9 × 4 μ: nomen specificum propter marginem longe incurvum.

Ad lignum udum decorticatumque *Salicis chlorophyllae*, Placer, montibus Sangre de Christo, Julio, 1896.

Stictis Edwiniae

Apotheciis tectis, globoso-clausis, dein erumpentibus, ore orbiculare, late apertis, extus nigro-furfuraceis vel tuberculatis, hymenio griseo, 300–500 μ; ascis octosporis, clavatis, iodo omnino caerulescentibus, 50–60 × 5–6 μ; paraphysibus linearibus, 2 μ lat.; sporis linearibus, hyalinis, plerumque guttulatis, 6–7-septatis, curvulis vel saepius sigmatodibus, 30–40 × 2–3 μ.

In ramis corticatis *Edwiniae Americanae*, Sugar Loaf, Septembri, 1900.

Ophiogloea

Apothecia superficialia, sessilia, gelatinosa, olliformia, extus atro-excipulata, hymenio laeticolore; epithecium nullum; hypothecium plectenchymaticum, crassum, hyalinum, iodo caerulescens; excipulum parenchymaticum, ad basim praecipue crassum, atro-avellaneum. Asci octospori, lineares, perlongi. Paraphyses simplices, longe clavulatae, fere hyalinae. Sporae filiformes, parallele congestae, aetate septulatae, hyalinae. Nomen propter formam sporarum textumque apothecii, *ὄφις, ὄφιος, ὁ*, anguis, *γλοιά, ἡ*, gluten.

A *Holwaya* differt forma cupulae excipuloque, ab *Agyriopside* excipulo, a *Bactrospora*, *Lahmia* et *Mycobacidia* contextu epitheciόque, a *Gorgonicipe* excipulo parenchymatico.

Ophiogloea linospora

Apotheciis superficialibus, sessilibus, gelatinosis, olliformibus, subgregariis, hymenio convexo, griseo, 500–800 μ alt., excipulo atro-avellaneo, parenchymatico, ad basim 125–150 μ cr., intus cellulis pallidis, oblongo-polygonatis, 20–25 μ diam., extus cellulis globosis nigris, 8–10 μ, pilis septatis concoloribus, 50–100 × 5 μ praeditis, 0.5–1.5 mm. lat.; ascis octosporis, perlinearibus, infra valde attenuatis, iodo non tinctis, 330–350 × 5–6 μ; hypothecio hyalino, iodo pulchre caerulescente, 80 μ cr.; sporis parallele congestis, filiformibus, hyalinis, deinde septulatis, maturitate expulsis varie curvatis et ad hymenium dense intertextis, 300–325 × 1–2 μ: nomen propter sporas perlineares.

Ad lignum decorticatum putridumque *Aceris glabri* (?), Fir Glen, Minnehaha, Septembri, 1900.

Scytopezis

Apothecia superficialia, sessilia, ceraceo-coriacea, hemisphaerico-cupulata, atra, pilosa, margine stellatim fisso; epithecium nullum; paraphyses praesentes; excipulum crassum, nigro-brunneum, pseudoparenchymaticum, pilis longis, atris dense obsitum; hypothecium crassum, hyalinum, prosenchymaticum. Asci octospori, cylindracei, inoperculati, iodo tincti. Sporae continuae, hyalinae, ellipticae, leves. Nomen propter texturam apothecii, *σκύτος, τό*, corium, *πέζις, ἡ*, fungus sessilis.

Est *Urnula* estipitata, excipulo parenchymatico.

Scytopezis stellata

Apotheciis sessilibus, caespitosis, hemisphaerico-cupulatis, margine incurvo, in 6–8 lobos alte stellatim fisso, hymenio umbrino-atro, paraphysibus 1–3-ramosis, septatis, apice dilute umbrinis, vix incrassatis, 3 μ lat., 1 cm. lat. et alt.; excipulo nigro-tomentoso, cellulis brunneis, 10–12 × 20 μ seriatim dispositis, ad marginem fuscioribus minoribusque in pilos confertos, contortos, septatos umbrinos, plerumque simplices, 250–350 × 4 μ productis, 150–250 μ crasso; hypothecio hyphis hyalinis 4–6 μ intricate intertextis, 400 μ cr.; ascis octosporis anguste cylindraceis, longe stipitatis, inoperculatis, non-iodatis, 350 × 12 μ; sporis recte monostichis, ellipticis, levibus, hyalinis, 22 × 11 μ: nomen propter marginem stellatim fissum.

Ad ramum vetustum in terra muscosa sepultum, Minnehaha, Septembri, 1902.

Dermatea macrospora

Apotheciis sparsis, numquam caespitosis, sessilibus, innato-erumpentibus, cortice elevata marginatis, ceraceo-coriaceis, scutellatis vel disciformibus, 0.8–1.2 mm. diam.; epithecio distincto, tenui, brunneo, hymenio brunneo-fulvo, 150 μ cr., paraphysibus linearibus, vix clavulatis, parce ramosis, insuper dilute fulvis, 3 μ lat.; hypothecio prosenchymatico, fere parenchymatico, fulvo, 100 μ cr.; excipulo cum hypothecio continuo similique, pallide fulvo, extus pilis fasciculatis ochraceis 100 × 5 μ minute tuberculato, margine libero, elevato, lobato; ascis octosporis, late clavato-oblongis, non-stipitatis, iodo non-tinctis, sporis farctis, 110–130 × 25–30 μ; sporis crebro et irregulariter distichis, raro oblique monostichis, elliptico-oblongis, rectis vel curvulis, levibus, intus granulatis, hyalinis, 33–45 × 8–12 μ.

Ad lignum *Salicis*, Placer, montibus Sangre de Christo, Julio, 1896. *D. inclusae* Peck affinis, sed colore, sporis majoribus margineque differt.

Helotium marginatum

Apotheciis stipitatis, gregariis, ceraceis, scutellatis, hymenio exacte ochraceo, ½–1 mm. lat., paraphysibus linearibus, septatis, hyalinis, 2 μ lat.; excipulo glabro, cellulis fusiformibus, brevibus, ochroleuco, margine pallidiore; stipite ceraceo, crasso, aequali, sparse albo-piloso, albido-ochroleuco, 300 μ alt. et lat.; ascis octosporis, clavulatis, stipitatis, iodo leviter tinctis, 100–110 × 8–10 μ; sporis monostichis vel irregulariter distichis, elliptico-fusiformibus, rectis vel curvulis, levibus, hyalinis, plerumque guttulatis, 16–18 × 4–5 μ: nomen propter marginem pallidum.

Ad ramos corticatos *Salicis*, placer, montibus Sangre de Christo, Julio, 1896. *Helotio carpinicolae* Rehmet *H. Ostruthii* (Saut.) Sacc. affinis.

Allophylaria Senecionis

Apotheciis superficialibus, stipitatis, laxe gregariis, ceraceo-coriaceis, subdiaphanis, cupulatis, glabris, ochroleucis, cellulis excipuli linearibus, 50–75 × 5 μ, margine irregulariter crenulatis, 500–800 μ lat.; stipite glabro, aequali, ochroleuco, in cupulam abrupte eunte, 200–400 μ alt., 100 μ lat.; ascis octosporis, lineari-clavatis, stipitatis, iodo non tinctis, 50 × 5–6 μ; paraphysibus lineari-subclavulatis, hyalinis, 2 μ lat.; sporis distichis, oblongo-fusiformibus, levibus, plerumque rectis, hyalinis, 10–12 × 2–3 μ.

In caulibus emortuis *Senecionis blitodis*, Mount Garfield, Augusto, 1901. Est *A. nanae* affinis, sed forma coloreque differt.

Dasyscypha incarnata

Apotheciis breviter stipitatis, sparsis, ceraceis, primitus globoso-clausis, dein hemisphaerico-apertis, extus pallide incarnatis, sparse pilosis, ad marginem dense lanatis ciliatisque, pilis strictis, septatis, hyalinis, parallelis, 80–100 × 2–3 μ, deorsum brevioribus, ad stipitem ramoso-tortuosis, hymenio laete incarnato, 1/3–1 mm. diam.; stipite pallidiore, 1/3 mm. alt.; ascis octosporis, oblongis, late stipitatis, iodo caerulescentibus, 50–60 × 4 μ; paraphysibus linearibus, simplicibus, numerosis, parce septatis vel continuis, granulis seriatis citrinulis praeditis, 2–3 μ; sporis distichis, oblongis, rectis vel curvulis, hyalinis, 8–10 × 1½–2 μ: nomen propter hymenium incarnatum.

Ad lignum decorticatum *Piceae Engelmannii*, Dark Cañon, Septembri, 1900. Ad *D. subtilissimam* (Cooke) Sacc. spectat.

Dasyscypha rubrifulva

Apotheciis superficialibus, sessilibus, gregariis, carnoso-ceraceis, globoso-cupulatis, siccitate clausis, udis apertis, extus praecipue margine laete fulvis, aetate brunneis, hymenio luteo, ochroleuco vel cremeo, pilis simplicibus, strictis, continuis, plerumque dense et minute tuberculatis, lilaceis vel purpureis, raro rubro-brunneis, 100–150 × 2–3 μ densissime praeditis, 1/3–1 mm. diam.; ascis octosporis, oblongis, brevioribus, iodo non caerulescentibus, 80 × 10 μ; paraphysibus linearibus, simplicibus, 2 μ lat.; sporis distichis, botuliformibus, utrinque obtusis, valde curvatis, levibus, hyalinis, intus minute granulosis, 16–18 × 4 μ: nomen propter apothecii colorem.

In ramis vetustis ignotis, Minnehaha, Septembri, 1900.

Neottiopezis macrospora*

Apotheciis sessilibus, cupuliformibus, aquose carnosis, udis fere hygrophanis, extus obsolete micaceis, tomentosis, incarnatis, hymenio concolore, margine distincto, pallidiore, crenulato-dentato, 3–6 mm. lat. et alt.; paraphysibus linearibus vel clavulatis, septatis, clava 5–8 μ lat., insuper granulis brunneis minutis farctis; hypothecio hyalino, 200 μ cr., pseudoparenchymatico; excipulo ad marginem exacte pseudoparenchymatico, 150 μ cr., cellulis 20 μ diam., pilis brevibus, septatis, curvatis, hyalinis, 50–80 × 8 μ praedito; ascis octosporis, cylindraceis, stipitatis, operculatis, iodo non tinctis, 350 × 22 μ; sporis oblique monostichis, raro distichis, naviculatis, leviter asperatis, dense vacuolatis, 40–42 × 16–18 μ: nomen propter sporas permagnas.

Ad terram inter muscos udos, Jack Brook, Minnehaha, Augusto, 1899.

Scutellinia chaetoloma

Apotheciis superficialibus, gregariis, ceraceo-carnosis, cupuliformibus, saepe irregulariter cochleatis, griseis, extus pilis sparsis, acutis, brunneolis, 270 × 8 μ, margine longe ciliato pilis erectis, strictis, fasciculatis, septatis, pallide brunneis, 560 × 8 μ, hymenio albido vel griseo, 5–22 mm. lat. et 6–10 mm. alt.; paraphysibus linearibus, vix clavulatis, raro bifurcatis, 3 μ lat.; ascis octosporis, cylindraceis, 300 × 19 μ; sporis monostichis, ellipticis, levibus, vacuolatis, 25–27 × 12–13 μ: nomen propter pilos marginis longos fasciculatosque, *χαῖτη, ἡ*, coma, *λῶμα, το*, lacinia.

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* Pro *Neottiella* Cooke, nomine hybrido: πέζις, ἡ, fungus sessilis.

Ad lignum udum et ad acus *Piceae*, Jack Brook, Minnehaha, Augusto, 1899.

Scutellinia dispora

Apotheciis sparsis, ceraceo-carnosis, scutellatis, margine setis brunneis brevibus, attenuatis, 200 × 20 μ praedito, extus pilis similibus brevioribus, disco miniato-rubro, 3–4 mm. diam.; paraphysibus linearibus, ad apicem valde turgidis, granulis coccineis dense farctis, 10–12 μ cr.; ascis octosporis, clavulatis, 185 × 20–23 μ; sporis irregulariter dispositis, levibus, hyalinis, gutta magna praeditis, forma valde diversis, aliis late ellipticis, 23–25 × 17–19 μ, aliis sphaericis, 23–27 μ, frequenter formis duabus in asco unico: nomen propter sporas diversas.

Ad lignum udum muscosumque, Cheyenne Cañon, Colorado Springs, Julio, 1894.

Scutellinia heterospora

Apotheciis sessilibus, gregariis, scutellatis, hymenio miniato, extus concoloribus, pilis acutis, septatis, atro-brunneis, 300 × 20 μ, margine pilis longissimis acuminatis, septatis, 1,000 × 27 μ, brunneo-ciliato, 3 mm. lat.; paraphysibus clavulatis, septatis, granulis aurantiaceis fusiformibus farctis, 4 μ lat., clava aurantiacea, 8–10 × 20–25 μ; ascis octosporis, late cylindraceis, breviter stipitatis, 275 × 20 μ; sporis monostichis, diversis, quattuor majoribus, ellipticis, asperulatis, vacuolatis, 24 × 14 μ, quattuor minoribus, fere vel exacte sphaericis, hyalinis, levibus, 11 μ diam.: nomen propter sporas dissimiles.

Ad terram muscosam, Minnehaha, Augusto, 1899.

Scutellinia irregularis

Apotheciis sessilibus, gregariis, irregulariter cupulatis, demum concavis, hymenio griseo-albido, fere glaucescente, extus brunneogriseis, pilis brunneis, 100 × 8 μ, margine pilis strictis, septatis, 325 × 8 μ brunneo-ciliato, 4–10 mm.; paraphysibus clavulatis, septatis, 3 μ lat.; ascis octosporis, cylindraceis, 200 × 16 μ; sporis monostichis, ellipticis, asperatis, biguttatis, 15 × 8 μ: nomen propter formam apothecii.

Ad trabes putrescentes *Piceae* sub ponte, Jack Brook, Minnehaha, Augusto, 1899. *S. Jungneri* Henn. affinis.

Sepultaria heterothrix

Apotheciis sepultis, ore integro, demum emergentibus et ore in dentes triangulares findente, hymenio ochraceo-brunneo, extus brunneis, pilis brevioribus, simplicibus, flexuosis, septatis, 100–150 μ long., longioribus similibus, nonnumquam 1-ramosis, 700–1000 μ, 2–2.5 cm. lat., 2 cm. alt.; paraphysibus clavulatis, septatis, vix granulatis; ascis lineari-clavatis, octosporis, 216 × 19 μ; sporis oblique monostichis, late ellipticis, levibus, uniguttatis, 20 × 14 μ: nomen propter pilos excipuli diversos.

In terra foliosa populeti, Ruxton Park, Augusto, 1899. *S. Geasteri* (B. & Br.) affinis.

Macropodia urceolata

Apotheciis carnosis, cupulatis, stipitatis, stipite in radiculas tres vel quattuor 5–10 mm. long. abeunte, omnino vel deorsum densissime griseo-lanato, hymenio ochraceo-brunneo, extus concoloribus vel fuscioribus, furfuraceo-tuberculatis, cellulis tuberculorum trigonorum in fasciculos pilorum brevium hyalinorum productis, margine pallidiore, incrassato, lacerato crenatoque, 1–2.5 cm. lat., 5–15 mm. alt.; paraphysibus clavulatis, septatis, viridi-guttatis, 4 μ lat., clava 8–9 μ lat.; ascis octosporis, cylindraceis, breviter stipitatis, 325 × 22 μ; sporis oblique monostichis, ellipticis, levibus, hyalinis, 24 × 14 μ: nomen propter formam apothecii.

In arena aquosa, Jack Brook, Minnehaha, Augusto, 1899.

Humaria ochroleuca

Apotheciis sessilibus, solitariis, urceolatis vel cupulatis, demum nonnumquam convexo-expansis, ceraceo-carnosis, hymenio ochroleuco, 3–6 mm. lat., 2–6 mm. alt., paraphysibus linearibus, hyalinis, numerosis, 3 μ lat.; hypothecio hyalino, hyphis dense intertextis, 170 μ cr.; excipulo ochroleuco, 125 μ cr., ex cellulis rotundis vel polygonatis, saepe seriatis, 16–20 μ diam., concreto, minute micaceo vel glabro, margine eximie albido-crenulato, sub margine zona pallide brunnea; ascis octosporis, linearibus, longe stipitatis, iodo non tinctis, 270 × 11 μ; sporis irregulariter monostichis, ellipticis, levibus, hyalinis, 19 × 11 μ: nomen propter colorem apothecii.

Inter muscos et in glarea ripis udis, Engelmann Cañon, Augusto, 1895, Breckenridge, Augusto. 1896, Jack Brook, Minnehaha, Augusto, 1899. *H. subcrenulatae* Clem. affinis.

Plicaria chlorophysa

Apotheciis sessilibus, solitariis, carnosis, cupuliformibus, raro concavo-expansis, hymenio brunneo, extus ochraceo-brunneis, furfuraceo-tuberculatis, margine integro, 5–12 mm. lat., 3–4 mm. alt.; paraphysibus clavatis, septatis, clava saepe granulis olivacei-viridibus farcta, 11 μ lat., nodis regulariter in cellulis magnis, sphaericis vel clavatis tumidis; ascis octosporis, cylindraceis, 275 × 16 μ; sporis monostichis, ellipticis, levibus, hyalinis, 18 × 11 μ: nomen propter colorem clavae paraphysium.

Ad lignum udum vetustumque, Jack Brook, Augusto; ad fimum udum, Castle Cañon, Septembri, 1900. *P. fimeti* (Fuckel) Rehm affinis.

Heteroplegma

Apothecia superficialia, sessilia, carnosa, hemisphaerico-cupulata, furfuraceo-excipulata, magna; epithecium nullum; paraphyses praesentes; hypothecium percrassum, hyalinum, trilaminatum, lamina superiore et inferiore pseudoparenchymaticis, medullari hyphis parallelis intertextisque, tramitiforme; excipulum tenue, filis brevibus tomentosum. Asci octospori, cylindracei, iodo valde caerulescentes. Sporae continuae, hyalinae, ellipticae. Nomen propter hypothecium laminatum, ἕτερος, dissimilis, πλέγμα, τό, vimineum.

Est *Plicaria* hypothecio heteromorpho.

Heteroplegma caeruleum

Apotheciis sessilibus vel substipitatis, solitariis vel dense gregariis, cupulatis vel urceolatis; ore clauso, dein late aperto, carne lacte caerulescente succosa, pulchre caerulea, ad basim 2–5-sulcatis, hymenio laete olivaceo, paraphysibus clavatis, septatis, insuper olivaceis, 4–5 μ lat., 5–8 cm. lat., 3–6 cm. alt.; hypothecio duabus lamellis pseudoparenchymaticis, fibrillis hypheis connexis composito, crasso; excipulo cremeo-olivaceo ad basim pulcherrime caeruleo, tuberculis fibrosis minutis isabellinis tomentoso; ascis octosporis, lineari-cylindraceis, stipitatis, iodo omnino caerulescentibus, 275–300 × 12–15 μ; sporis oblique vel irregulariter monostichis, ellipticis, asperatis, hyalinis, 18–20 × 8–9 μ: nomen propter colorem lactis.

Ad terram udam umbrosamque, Dark Cañon, Septembri, 1899.

Heteroplegma crenatum

Apotheciis sessilibus, plerumque solitariis, aquose carnosis, irregulariter hemisphaerico-cupulatis, hymenio umbrino-castaneo, paraphysibus clavulatis, simplicibus, dilute umbrinis, apice 5 μ lat., 2.5–5 cm. lat., 2–3 cm. alt.; excipulo cellulis polygonis minutis hyphis intertextis tomentoso, pallide umbrino, siccitate griseo-furfuraceo, 150 μ cr., margine crenis nigro-furfuraceis, 4 mm. lat., 2 mm. alt., praedito; hypothecii lamina superiore inferioreque 600 μ crassa, medullari 500 μ; ascis octosporis, cylindraceis, truncatis, operculatis, operculo et ore iodo valde tinctis, alibi dilute coloratis, 300 × 28 μ; sporis oblique vel irregulariter monostichis, ellipticis, levibus, hyalinis, 22 × 14 μ: nomen propter marginem crenatum: typus!

Ad terram pinguem udosamque inter muscos, Ruxton Brook, Minnehaha, Augusto, 1902.

Phleboscyphus* macropus

Apotheciis stipitatis, solitariis, ceraceo-carnosis, pileatis, sed ad centrum excavatis, hinc umbilicatis, hymenio umbrino, subtus minute scabris, griseo-albidis, 3–4 cm. lat., 1 cm. alt.; excipulo pseudoparenchymatico, pallide umbrino, cellulis oblongo-polygonatis, fere seriatis, 20 × 30 μ composito, 100 μ crasso, ad marginem in pilos breves torulosos septatos 25–50 μ abeunte, margine castaneo-crenulato; hypothecio crasso, hypheo-parenchymatico, hyalino, 800 μ cr.; stipite solido, longo, ceraceo-cartilagineo, compresso, alte 3–4-sulcato, supra valde incrassato, scabro, albido-cremeo, 4 cm. long., infra 7 mm. lat., insuper 2 cm. lat., sulcis 2–3 mm. alt. et cr.; excipulo ut in apothecio, sed cellulis oblongioribus, exacte seriatis, 150–175 μ cr., acie pilis sparsis fuscata; interiore dense pseudoparenchymatica; ascis octosporis, elongato-cylindraceis, stipitatis, inoperculatis, iodo non tinctis, 300 × 20 μ; paraphysibus clavulatis, simplicibus, septatis, clava umbrina, 9 μ lat.; sporis irregulariter monostichis, late ellipticis, levibus, hyalinis, gutta magna 12–13 μ praeditis, 20–22 × 12–14 μ: nomen propter stipitem longum.

Ad terram udam in antro saxoso, Ruxton Brook, Minnehaha, Septembri, 1902: a *P. acetabulo* (L.), differt praecipue stipite longiore et apothecio umbilicato tomentosoque.

Phleboscyphus olivaceus

Apotheciis stipitatis, caespitosis, irregulariter cupuliformibus, deinde laceratis, latis, hymenio viridi-olivaceo, valde corrugato-sulcato vel papillato, extus brunneo-olivaceis, furfuraceo-tuberculatis, margine fusciore, 4–5 cm. lat., 2–2.5 cm. alt.; stipite lato, similiter furfuraceo coloratoque, 1–2-sulcato, infra mycelio obsito, coalito, 2–2.5 cm. alt., 1.5–2 cm. lat.; ascis octosporis, anguste cylindraceis, breviter stipitatis, iodo tinctis, 350 × 14 μ; paraphysibus linearibus, septatis, hyalinis, 3–4 μ lat.; sporis monostichis, ellipticis, asperatis, hyalinis, 19 × 8 μ; nomen propter colorem apothecii.

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* *Acetabula* Fr. 1823, Fckl. 1869, propter *Acetabulum* L. 1735 concidit. *Phleboscyphus* (φλέψ, φλεβός, ἡ, vena, σκύφος, ὁ, calix, propter venas apothecii) pro *Paxina* O. K., nomine hybrido, praepositum est.

Ad terram udam, Jack Brook, Minnehaha, Augusto, 1899.

Phleboscyphus radicatus

Apotheciis stipitato-radicatis, solitariis, ceraceo-carnosis, fere cartilagineis, urceolatis vel cupulatis, hymenio ochroleuco, ad basim 3–4-sulcato-corrugato, extus concoloribus, furfuraceo-tuberculatis, 1–2 cm. alt., 1–2 cm. lat.; excipulo indistincte parenchymatico, cellulis irregularibus, polygonato-rotundis, ad marginem in grumos 50 × 35 μ, vel in pilos fasciculatos hyalinos 80 μ long. productis, 100 μ crasso; hypothecio pseudoparenchymatico, percrasso, 800–1000 μ cr.; ascis octosporis, cylindraceis, stipitatis, non-iodatis, inoperculatis, 275 × 16 μ; paraphysibus 1–2-ramosis, septatis, vix clavulatis, apicem fuscatis, 4–5 μ lat.; sporis recte vel oblique monostichis, ellipticis, levibus, biguttatis, 20–22 × 10–11 μ; stipite brevissimo, 5–6 mm. alt. × 4 mm. lat., hypogaeo vel subhypogaeo, lacunoso, in fibris densis producto, radice simili: nomen propter stipitem radicatum.

In locis udis sub saxis, Ruxton Brook, Minnehaha, Septembri, 1902.

Helvella pileata

Apotheciis solitariis, ceraceo-carnosis, campanulato-pileatis vel verpiformibus, vix vel haud lobulatis, levibus, umbrinis, subtus levibus, albido-tomentulosis, formis campanulatis 1 cm. alt., 2 cm. lat., verpiformibus 4 cm. alt., 2.5 cm. lat.; hypothecio hypheo-parenchymatico, 250 μ cr.; excipulo hyalino, pseudoparenchymatico, cellulis oblongis, exacte seriatis, 25–30 × 15–18 μ, ad marginem in pilos continuos hyalinos 30–50 × 5–7 μ productis, 125 μ lat.; stipite albo, elongato, levi, tomentuloso, farcto-subsolido, 6–8 cm. alt. × 3–7 mm. lat., excipulo seriatim parenchymatico, sed cellulis ad marginem in grumis 45 × 25 μ coacervatis, 200 μ cr., interiore trilaminata, lamella prima hyphis dense et intricate intertextis, 400 μ lat., secunda hyphis parallelis congestis, 250 μ cr., medullata hyphis septatis strictis 3–4 μ lat., laxissime intertextis; centro cavo, 2 mm. lat.; ascis octosporis, cylindraceis, non-stipitatis, inoperculatis, non-iodatis, 275 × 20 μ; paraphysibus clavatis, parce ramosis, septatis, 4–5 μ lat., clava dilute umbrina, 8–10 μ lat.; sporis plerumque oblique monostichis, late ellipticis, levibus, hyalinis, gutta magna 10 μ praeditis, 20 × 14 μ: nomen propter formam apothecii.

Ad terram et lignum udum, Jack Brook, Minnehaha, Septembri, 1902.

New Species of Fungi

By Charles H. Peck

Lepiota eriophora

Pileus thin, dry, broadly convex or nearly plane, densely squamose with brown rather compact and sometimes pointed woolly scales, flesh white; lamellae thin, narrow, close, free, whitish, becoming darker with age or in drying; stem equal, hollow, clothed with brown tomentum; spores minute, 4 μ long, 2–2.5 μ broad, often adhering together in small groups or masses and then appearing like unequal angular spores.

Pileus about 2.5 cm. broad; stem 2–3 cm. long, 2–3 mm. thick.

West Virginia. C. G. Lloyd. This species resembles *L. felina* and *L. fuscosquamea*, from both of which it differs in its smaller spores and more dense and paler tomentose veil.

Marasmius subpilosus

Pileus thin, even or faintly rugulose in the center, striate on the margin, pruinosely pubescent, convex or nearly plane, sometimes slightly umbilicate, whitish, often tinged with yellow or brown in the center; lamellae rather broad, ventricose, adnate, subsinuate, white, the edge minutely ciliate; stem slender, tough, stuffed or hollow, pruinosely pubescent, grayish tomentose at the base, reddish brown, white at the top.

Pileus 1–2 cm. broad; stem 2.5–5 cm. long, 0.5–1 mm. thick.

Among fallen leaves and twigs in moist woods. Near Moscow Mountains, Idaho. Autumn. L. F. Henderson. This species is well marked by the pubescence of the pileus and stem but the hairs are so minute and thinly placed that to the naked eye they appear like a mere pruinosity, but under a strong lens they are readily seen and also the cilia of the edge of the lamellae.

Pholiota fulvosquamosa

Pileus fleshy, rather thin, convex becoming nearly plane, dry, adorned with numerous appressed tawny or brownish fibrillose scales, concentrically cracked about the disk, flesh white, becoming brownish where cut, taste and odor of radishes; lamellae narrow, close, attenuated toward the stem and attached to a narrow collar, whitish becoming pinkish cinnamon; stem equal, rigid, stuffed or hollow, adorned below with numerous erect subfloccose tawny scales, glabrous above and a short distance below the ample persistent annulus which is white above and tawny floccose squamulose below; spores elliptic, 8 μ long, 4–5 μ broad.

Pileus 6–12 cm. broad; stem 5–8 cm. long, 8–10 mm. thick.

About the base of oak trees. Agricultural College, Michigan. September. B. O. Longyear.

Flammula velata

Pileus fleshy, thin toward the margin, convex, moist, sulphur yellow, reddish or orange in the center, the margin persistently incurved, flesh yellow or greenish yellow, taste mild; lamellae arcuate, adnate or slightly decurrent, 5 mm. wide, pale yellow, becoming rusty brown or snuff-color with age, concealed when young by the conspicuous but thin somewhat webby yellowish white veil; stem short, slender, flexuous, solid, fibrillose, sulphur yellow above, brownish below, somewhat tomentose at the base; spores elliptic, 5–8 μ long.

Pileus 2–4 cm. broad; stem 2.5–4.5 cm. long, 2–4 mm. thick.

Woods along small streams. Base of Moscow Mountains, Idaho. July. L. F. Henderson. The strongly developed veil is a prominent character of this species. Its moist pileus places it in the section *Uda*.

Cortinarius punctifolius

Pileus fleshy, thin on the margin, convex or nearly plane, dry, slightly fibrillose and squamulose, yellowish brown, sometimes tinged with green, flesh yellow; lamellae broad, subdistant, deeply and abruptly excavated at the inner extremity, adnexed or nearly free, yellowish brown tinged with green, becoming cinnamon-color, dotted with yellow; stem subequal, often flexuous or irregular, glabrous or slightly fibrillose, striate, yellow, varied with bluish green; spores broadly elliptic or subovate, 5–7 μ long, 4–5 μ broad.

Pileus 2.5–6 cm. broad; stem 2.5–5 cm. long, 5–10 mm. thick.

Woods at the base of Moscow Mountains, Idaho. Summer. L. F. Henderson. A peculiar species well marked by the yellowish dots of the lamellae, a character that has suggested the specific name. The species belongs to the section *Dermocybe*.

Bolbitius Glatfelteri

Pileus thin, conical or subcampanulate, soon expanding with the margin curving upwards, sometimes umbonate, glabrous, very viscid, widely striate on the margin, white, yellowish or tawny in the center; lamellae close, rather narrow, subventricose, free, pallid, becoming ferruginous and pulverulent; stem equal or slightly tapering upward, hollow, slightly striate above, slightly squamulose or furfuraceous when young, becoming glabrous and shining, pure white; spores 12–16 μ long, 8–10 μ broad.

Pileus 2–3 cm. broad; stem 5–10 cm. long, 4–5 mm. thick.

Gregarious or cespitose on rotted manure. Missouri and Illinois. April and May. N. M. Glatfelter. The species is apparently related to *B. sordidus* Lloyd, from which it may be separated by its larger spores and more narrow lamellae.

Fomes albogriseus

Pileus elongated ungulate, externally hard, lignose, concentrically sulcate, azonate, the younger parts of the crust isabelline or pale gray, suffused with a slightly detersible pruinosity, the older parts becoming uneven, rimose and blackish gray, inner substance somewhat soft, friable, whitish; pores minute, obscurely stratose, white within, their mouths pallid or isabelline.

Pileus 7–35 cm. long, 10–25 cm. broad, 5–15 cm. thick.

Trunks of tamarack and white pine. Kent county, Michigan. July. B. O. Longyear. In size and shape this fungus resembles elongated forms of *F. fomentarius*, and it does not differ greatly in color from faded specimens of that species. In the character of its annual increments it resembles *Polyporus juniperinus* Schrenk. Each new increment is a little smaller at its base than the adjacent part of the one preceding it. Consequently the mouths of the marginal pores of the older increments can be seen in the furrows that separate the increments. *Polyporus officinalis* is said to inhabit the larch, but its pileus is described as variegated with yellowish and fuscous zones and as having a farinaceous odor, a bitter taste and short pores, characters not shown by our fungus.

Hydnum conigenum

Pileus coriaceous, 1–2 cm. broad, obconic, nearly plane above, even, minutely downy, grayish orange or yellowish orange, sometimes split on the margin, substance fibrous, azonate, orange brown; spines short, decurrent, whitish becoming brown; stem slender, central or sometimes eccentric, colored like the pileus, thickened at the base by a dense spongy mass of orange-colored tomentum; spores globose, colored, 4–5 μ in diameter.

Fallen cones of bull pine, *Pinus ponderosa.* Base of Moscow Mountains, Idaho. Autumn. L. F. Henderson. Similar in color to *H. aurantiacum*, but differing in its small size, slender stem, even pileus, zoneless substance and peculiar habitat.

Hydnum cyaneotinctum

Pileus slightly tough but of a soft spongy texture, nearly plane above, minutely tomentose, whitish or buff, tinged with blue on the margin, flesh isabelline or pale buff above, sometimes tinged with blue below; spines short, pallid, becoming ferruginous brown; stem short, firm, covered nearly to the pileus with a dense spongy isabelline tomentum; spores globose, verrucose, colored, 4 μ in diameter.

Pileus 3–6 cm. broad; stem about 2.5 cm. long.

Orris Island, Maine. September. Miss H. C. Anderson. This species is related to *H. suaveolens*, from which it differs in the color of its flesh, in the absence of odor and in the dense tomentum of the stem.

Clavaria densissima

Tufts 7–10 cm. high, nearly as broad, very dense, closely and intricately branched from the base, the branches solid, white within, often compressed, very crowded, repeatedly and irregularly branching, sometimes anastomosing, pale ochraceous when dry, the ultimate branches more or less compressed and dilated, terminating in two or more blunt or pointed whitish tips; spores naviculoid, often uninucleate, 8–10 μ long, 4–5 μ broad; mycelium whitish.

Much-decayed vegetable matter in mixed woods. Greenville, Michigan. October. B. O. Longyear. Near *C. densa* and *C. condensata*, but from the latter it differs in color and from the former in its more compact mode of growth, compressed branches, more narrow spores, and in having the tips of the branches differing in color from the branches themselves. The branches appear glabrous to the naked eye, but under a lens they have a minutely velvety appearance. This indicates a relationship to the genus

Lachnocladium, but it is not clearly shown by the dried specimens that the texture is coriaceous.

Cytosporella macrospora

Perithecia prominent, at first covered by the epidermis, then erumpent, orbicular, sometimes oblong by confluence, blackish within, imperfectly plurilocular, 1–2 mm. broad; spores obovate or broadly elliptic, hyaline, 10–15 μ long, 7–8 μ broad, supported by slender sporophores which are longer than the spores.

Branches of cottonwood, *Populus deltoides*. Near Chicago, Illinois. May. H. Hasselbring. Remarkable for the large size of its spores. Its nearest ally seems to be *C. Populi* Oud., but the spores of the latter are described as almost perfectly globose and 7 μ in diameter.

Sepedonium macrosporum

Hyphae creeping or erect, hyaline, septate, branched, forming a white downy coat over the matrix, the ultimate branches ending in a long subulate point; spores large, globose, colorless, 30–40 μ in diameter, with a thick epispore and a large shining nucleus.

On some small *Clavaria*. New Jersey. E. B. Sterling. Easily distinguished by its peculiar habitat and its large even globose colorless spores.

Morchella punctipes

Ascomate conical, subacute, free to the middle, longitudinally ribbed, the costae sparingly branched toward the margin, connected by transverse veins, pallid with the edges blackish in the dried specimens; stem hollow, swollen toward the base, minutely squamulose or furfuraceous, whitish; asci cylindric, 8-spored; spores elliptic, even, 20–30 μ long, 14–18 μ broad.

Ascomate 1.5–2.5 cm. long; stem 7–10 cm. long, 1–2 cm. thick.

Agricultural College, Michigan. June, B. O. Longyear. This species is closely allied to *M. gigas*, *M. rimosipes* and *M. semilibera*. From the first two it may be separated by the pileus being free from the stem, at least to the middle, and from the last by its larger spores and squamulose stem. The adornment of the stem consists of small conical points which are sometimes darker colored than the stem and are then more conspicuous. In larger specimens there are one to four perforations at the base, but no chinks as in *M. rimosipes*. The inner surface of the stem is glabrous.

Mitruliopsis gen. nov.

Ascomate fleshy, obovate or spathulate, stipitate; asci 8-spored, aparaphysate; spores filiform.

A genus related to *Mitrula* and *Spathularia*, but with filiform spores.

Mitruliopsis flavida

Ascomate fleshy, soft, tender, stipitate, very variable, obovate or subspathulate, terete or compressed, sometimes lobed at the base and decurrent on the stem, creamy yellow, flesh white; asci subfusiform, 120–160 μ long, 8-spored; spores filiform, hyaline, 60–80 μ long, 2 μ broad; stem equal or slightly tapering upward, pallid, hollow, 12–20 mm. long, 2–3 mm. thick.

Steep shaded banks. Near Moscow, Idaho. Autumn. L. F. Henderson. The hymenium is distinct from the stem and often lobed at the base. When the club is compressed the lobes are generally decurrent and then the fungus might easily be taken to be a species of *Spathularia*.

Helvella brevissima

Pileus irregular, convolute, with the deflexed margin free, blackish when dry, whitish or pallid beneath, 1–2 cm. broad; stem very short, even, solid, whitish or pallid, 1–1.5 cm. long, 3–4 mm. thick; asci cylindric; spores elliptic, commonly binucleate, 15–20 μ long, 10–12 μ broad; paraphyses filiform, thickened at the top and there brown.

Ground. California. W. R. Dudley.

Plectania rimosa

Cups 1.5–2.5 cm. broad, cupulate, the margin involute, externally minutely hairy, black, with a few simple or sparingly-branched costae extending upward from the base, hymenium black, rimose; stem short, irregular or compressed, often tapering downward; asci cylindric; spores unequally elliptic or oblong, two- to four-nucleate, uniseriate, 22–30 μ long, 12–14 μ broad, the brown paraphyses slightly thickened above.

California. W. R. Dudley.

Peziza convoluta

Cups sessile, irregular, externally glabrous, wrinkled or vaguely reticulated, yellowish brown or tawny brown, the margin widely spreading, variously curved, deflexed, wavy or contorted, the hymenium convolutely folded, tawny brown; asci cylindric; spores uniseriate, elliptic or oblong, 20–22 μ long, 12–15 μ broad.

Sandy soil, California. W. R. Dudley. The abundant white mycelium binds together a ball of sand which adheres to the base of the specimens. The remarkable feature of this species is the irregularity of its cup with the convolutions of the hymenium.

GEOLOGICAL HALL, Albany, N. Y.

A fossil Petal and a fossil Fruit from the Cretaceous (Dakota Group) of Kansas

By Arthur Hollick

Included in a collection of fossil plant remains from the Cretaceous (Dakota Group) of Kansas, recently obtained by the New York Botanical Garden from Mr. Charles H. Sternberg, of Lawrence, Kans., are two exceedingly interesting specimens — one representing a large petal, the other a fleshy fruit.

Petals, as fossils, are exceedingly rare, and I am not acquainted with any published figure of anything of the kind which can compare with ours, in regard to either size or satisfactory condition of preservation. Unfortunately, a portion of the upper part, including the apex, is gone, but it is sufficiently perfect to indicate what was its original shape, and the principal characters of the nervation are plainly discernible.

Careful examination and comparison has shown that, in all essentials, it agrees with the petals of some of our large-flowered magnolias, such as *M. foetida* Sarg. and *M. macrophylla* Michx., and as some ten species of *Magnolia*, founded upon more or less well-defined leaves, have been described from the Dakota group, I have decided to refer it to that genus.

The probabilities, of course, are that it belongs to a species to which one of the fossil leaves belongs, but as it is impossible definitely to connect the petal with any one of these a distinctive name is necessary, which should indicate that the fossil was a petal and not a leaf.

Magnolia palaeopetala sp. nov.

Petal apparently ovate-spatulate in outline, about 15 cm. long by 10 cm. broad, convex, laterally constricted and incurved at the base; margin entire, wavy or flexuous; nervation flabellate, dictyodrome, simple and well defined below, forking and thinner above, anastomosing, the areolae and reticulations becoming successively smaller and the nervilles finer, towards the margin. (*Fig. A.*)

Locality: Ellsworth Co., Kans.

It is apparent that this petal must have possessed a texture more or less coriaceous, as otherwise its preservation in such a relatively coarse medium as the Dakota sandstone would have been impossible, and this supposition is supported by the fact that the convexity of the surface, the incurving of the base and margin and the constriction of the former, all appear to have been characters of the living flower and not to be due to subsequent distortion by fossilization.

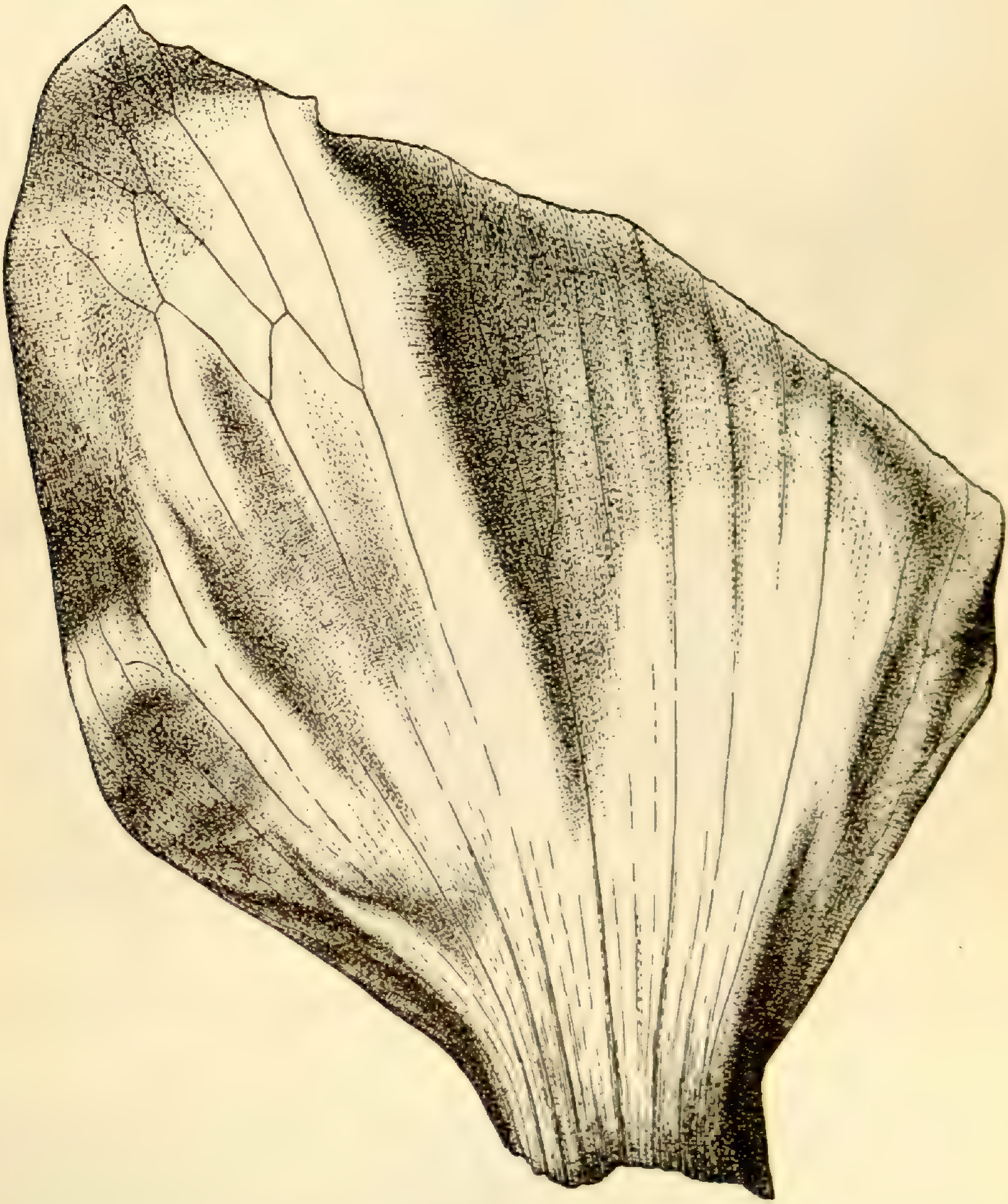

FIG. A. *Magnolia palaeopetala* Hollick.

The fruit is plainly that of a fig, and although some twenty-three species of *Ficus* have been described from the Dakota group they were based upon leaf-impressions alone. Only two specimens of fruit were known and these were too ill-defined to admit of specific description. ("Fruits of *Ficus*," Lesq. Fl. Dak. Group, 85. *pl. 10. f. 7, 8.* See our Fig. B, 2, 3.) They are incidentally mentioned however as being associated with leaves of *Ficus inaequalis* Lesq.

Specimens considerably more satisfactory were described and figured by Heer in 1874, from the lower Atane beds of Greenland — representing a geological horizon which is practically the equivalent of the Dakota group — under the name *Ficus protogaea* Heer* (Fl. Foss. Arct. 3^2: 108. *pl. 30. f. 5–7.* See our Fig. B, 4, 5, 6.)

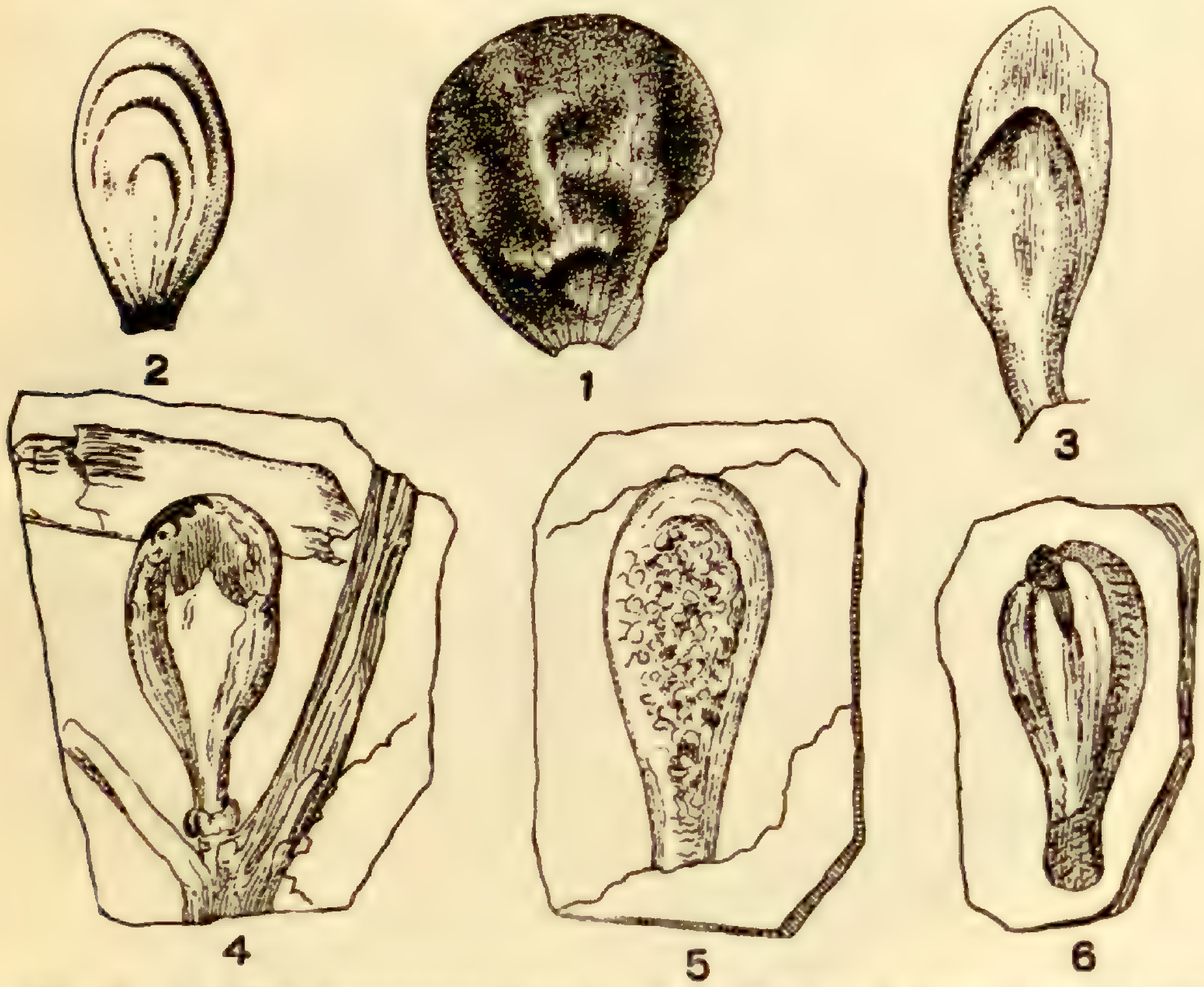

FIG. B. 1. *Ficus neurocarpa* Hollick. 2, 3. "Fruits of *Ficus*" (after Lesquereux). 4–6. *Ficus protogaea* Heer (after Heer).

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* The name *Ficus protogaea* was previously used by Ettingshausen, in 1867, in describing a fragmentary fossil leaf from the Cretaceous of Niederschoena in Saxony (Sitzb. Akad. Wiss. Wien, Math.-Nat. Cl. **55**: 249. *pl. 2. f. 5.*) In any revision of the genus it would therefore be necessary to rename these fruits. In this paper however it is not thought necessary to do anything more than to call attention to the fact.

These five specimens are the only ones which I have found recorded as occurring in the same geological horizon as that to which our specimen belongs, or in any strata which may be regarded as its equivalent, and none of them is equal to ours as a specimen, so far as may be judged from the figures.

Ficus neurocarpa sp. nov.

Fruit broadly obovate-spatulate in outline, 2.8 cm. long by 2.4 cm. maximum width, thick and wrinkled towards the middle, flattened more or less at or near the margin, minutely punctate and delicately nerved; primary nerves convergent but distinct and separated from each other at the base, divergent and becoming thinner and indistinct above, where they anastomose; secondary nerves very fine and apparently irregularly disposed. (*Fig. B, 1.*)

Locality: Ellsworth Co., Kans.

This fossil has very much the appearance of many dried herbarium specimens and it is evident that it must have possessed considerable consistency in order to retain its original shape, as it has done to a certain extent, under the pressure to which it must have been subjected.

Notes on Antillean Pines with Description of a new Species from the Isle of Pines

By W. W. Rowlee

During a trip to southern Florida, Cuba and the Isle of Pines last year, I made a special effort to compare the pines of these three regions, with the result that I am convinced that the pine of southern Florida, *P. heterophylla* of recent authors, is not identical with Grisebach's *P. Cubensis.* The cones of the Florida species are very different from those of the Cuban pine. *Pinus Cubensis* is apparently much closer in affinity to the Loblolly pine (*P. Taeda*) than to *P. heterophylla* and it is possible, though rather improbable, that the Loblolly and the Cuban pine are not specifically distinct.

The pines of the West Indies and the coast region of the southeastern United States grow under conditions of climate and soil very different from the species of the northern and western states. The vegetation associated with them records this, as it is decidedly xerophytic in tendency.

Fortunately the West Indian pines have not been encumbered with the synonymy that attaches to the Mexican species. Indeed it would seem that the recognized botanical species are fewer than the forms that are popularly recognized. We were told on the Isle of Pines that the natives distinguish five kinds of pines when cutting timber. We found sufficient warrant for two, but concluded that the other differences depended upon age and other individual rather than specific traits. One thing was very noticeable, namely, the great uniformity of the pine growths of the whole Antillean region. This was manifest not only among the pines themselves but also in the character of the accompanying plants. The shores washed by the Gulf Stream from its entry into the Caribbean Sea until it passes north of the frost line, whether island or continental, have a strikingly uniform flora. One of the effects apparently upon the pine is to increase the density and relative amount of the summer wood in the annual ring, thereby increasing the weight per cubic foot and also the hardness of the wood, hence the name hard pine. They are the heaviest pine woods known, indeed there are, so far as the writer is aware, no other coniferous woods whose weight equals them. Their wood is as heavy as that of white oak.

The ecological significance of the dense summer wood is, it seems to me, to be found in the necessity of these plants to adapt themselves to a very dry season. By its development the trunk of the tree is encased in dense layers of wood and the escape of water is thereby largely prevented. The dry winds and continuous heat of the region where the hard pines occur suggest that a response on the part of the plant might be expected. No soft pines grow under these conditions and other coniferous woods are scarce while the hard pines often form nearly pure forests.

Another result of my observation was the discovery of an apparently undescribed species on the Isle of Pines and from the position of the scales when the cone opens I propose for it the following name:

Pinus recurvata sp. nov.

Trees of medium to large size with wide-spreading and rounded top; bark of trunk vertically and horizontally fissured but not flaking off; wood very heavy (52 lbs. to cu. ft. when seasoned): branches roughened by scars of bracts and needle-clusters; bracts decurrent on the branch, brown with hyaline margins, recurved, deciduous above the prominent base, after the needles develop: sheath smooth, its scales ciliate on the margins, 0.5 cm. long; needles gray, 3 in a fascicle, 20 cm. long, 2 mm. wide, rounded and 12-striate on the outer, plane with prominent sharply angled midrib on the inner side, 6-striate each side of the midrib, finely and sharply serrate: cone when closed cylindrical, when open ovate, 10 cm. long, 5 cm. thick at the base; scales recurved, remaining compact at the base, 1 cm. wide, dark brown, apophysis inequilateral, slightly rounded and depressed, horizontal carina distinctly evident, umbo diamond-shaped, with a short straight prickle.

In general appearance, and in leaves and vesture of the branches, this species agrees closely with *P. palustris*. The cone is, however, only one half as large, and the depressed umbo and straight prickle are not like that species. Its cone is even more unlike that of *P. heterophylla* and *P. Cubensis*. The Mexican pine, *Pinus Montezumae*, has a cone more like this species than any other I have seen, but this is a five-needled pine. Specimens were collected at Santa Rosalie, Isle of Pines. The tree also occurs commonly over the island.

Of the several kinds of pine distinguished on the island by the natives, the wood of this species is preferred over all others for construction. It has been extensively exported to Cuba, and although the forests are showing considerable ability to regenerate and perpetuate themselves in spite of frequent burning, there is but a remnant left of what must have been originally a magnificent pine forest. The island is certainly well named. Several tracts have been boxed for turpentine but have not been utilized in recent years. It was said that the boxing was mainly done during our Civil War.

It grows commingled with what we considered *Pinus Cubensis* Grisebach, and was confined to the higher parts of the island but did not occur on the mountains.

Pinus Cubensis grows well down toward the shores of the island and in these situations we collected specimens which may be designated:

P. Cubensis anomala var. nov.

Tree 6–9 m. high: needles slender, 3 in a fascicle, bracts 6–8 mm. long, green on the young shoots and resembling the leaves of a spruce, and persistent during the first season.

Dr. Engelmann notes the same tendency in *Pinus serotina* where trees had been felled and new shoots subsequently developed, or posts from freshly cut trees set in the ground. (Trans. Acad. Sci. St. Louis, **4**: 183. 1880.)

The cones and needles of these trees did not present any departure from *P. Cubensis* and we concluded that the smaller size of the trees and the peculiar development of the bracts was due to the proximity of the sea or some other environmental cause. There were several trees near Jucaro Landing on the eastern side of the island. The reversion of the scales to what is generally considered the primitive form of the primary leaf of the pine is an exceedingly interesting phenomenon.

CORNELL UNIVERSITY.

The Polyporaceae of North America. II. The Genus Pyropolyporus[*]

By William Alphonso Murrill

The European species of this genus were first separated into a distinct generic group by Quélet in his "Enchiridion Fungorum" published in 1886. His genus *Phellinus* established at that time contained four species, *P. igniarius* (L.), *P. fulvus* (Scop.), *P. conchatus* (Pers.) and *P. salicinus* (Pers.), and was characterized as follows: "Pileus velvety, persisting; context corky; pores small, fulvous brown; spores ovoid, fulvous. Plants lignatile." The name *Phellinus*, however, is preoccupied by *Pheline* assigned in 1826 to a genus of the Ebenaceae. The new name *Pyropolyporus* here proposed refers to the use of some species of this group in ancient times for the purpose of keeping fire.

Synopsis of the North American Species

1. Pileus thick, ungulate, woody, margin obtuse, tubes several times stratified, the upper layers not dying before the lower. 2.
Not as above. 11.

2. Context yellowish brown. 3.
Context reddish orange; plants growing on trunks of *Juniperus*. 10.

3. Spores hyaline. 4.
Spores yellowish brown. 7.

4. Pileus becoming more or less rimose with age. 5.
Pileus covered even in age with a smooth horny crust. 6.

5. Pileus simple, sulcate, sometimes polished, margin usually narrow and rounded; not found on species of *Prunus*. 1. *P. igniarius.*
Pileus terraced, imbricate or semiresupinate, rarely sulcate, never polished, margin broad, making an obtuse angle; found on species of *Prunus*. 2. *P. fulvus.*

6. Context ferruginous, surface dark brown marked with narrow black concentric lines, tubes thin-walled, 5 to a mm. 3. *P. crustosus.*
Context tawny, surface black without lines and more sulcate, tubes smaller, thick-walled, 7 to a mm. 4. *P. Calkinsii.*

7. Pileus soon becoming rimose. 8.
Pileus not rimose, broadly sulcate, zonate, tubes thin-walled, spores 3μ in diameter, spines large and abundant; growing on *Quercus*. 5. *P. Everhartii.*

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[*] Read by invitation before the Botanical Society of America at Washington, January 1, 1903.

8. Tubes long, over 0.5 cm. each season, walls thin, pores large, 3 to a mm. 9.
Tubes very short, 0.1–0.5 cm. long each season, walls equalling tubes in thickness, pores small, 5 to a mm., spores globose, 4–5 μ, cystidia none; growing abundantly on *Robinia*. 6. *P. Robiniae.*

9. Spores globose, 3–4 μ in diameter, cystidia present; pileus blackish, very rimose, hymenium convex, margin truncate, at length hoary. 7. *P. praerimosus.*
Spores ellipsoidal, 7 × 9 μ, cystidia none; pileus dark brown, hymenium concave, margin not hoary. 8. *P. Underwoodii.*

10. Older pores visible in projecting annual layers, tubes 3–4 to a mm., thin-walled; pileus deeply furrowed, not rimose. 9. *P. juniperinus.*
Older pores not externally visible, tubes 1–2 to a mm., thicker walled; surface very rimose. 10. *P. Earlei.*

11. Spores hyaline. 12.
Spores yellowish brown. 15.

12. Cystidia abundant, pointed, dark brown; pileus thin, woody, rigid, tubes short, 5 to a mm. 11. *P. conchatus.*
Cystidia none. 13.

13. Context thick, woody, honey-yellow, surface encrusted, margin blunt. 12. *P. Haematoxyli.*
Context thin, punky, darker brown, surface without a crust, margin sharp. 14.

14. Pileus 10–25 cm. broad, covered with narrow shallow furrows, margin undulate or lobed, pores minute, 8–9 to a mm. 13. *P. Langloisii.*
Pileus smaller, deeply sulcate, pores larger, 6 to a mm.; growing on species of *Ribes*, very rarely on other shrubs. 14. *P. Ribis.*

15. Dissepiments thick, hymenium concolorous with context. 16.
Dissepiments thin, hymenium darker than context. 17.

16. Pileus very rimose, cystidia present; tubes fulvous, 7 to a mm., spores globose, 3.5–5 μ, cystidia 17–35 μ. 15. *P. Yucatanensis.*
Pileus scarcely rimose, encrusted, becoming smooth, cystidia absent; margin undulate, tubes 8 to a mm., spores globose. 16. *P. senex.*

17. Pileus hard and heavy, surface sulcate, brown, clothed with lime-white hair, spores 3.5 μ, spines 40–60 μ. 17. *P. linteus.*
Upper layers of pileus dead, projecting 1–2 cm. beyond the lower, tube strata separated by thin layers of context, tubes 7 to a mm., spores 5–7 μ, cystidia absent. 18. *P. Jamaicensis.*

1. **Pyropolyporus igniarius** (L.)

Boletus igniarius L. Sp. Pl. 1176. 1753; Tourn. Inst. **1**: 562. *pl. 330. f. A.* 1719.

Polyporus igniarius Fries, Syst. **1**: 375. 1821.

Fomes igniarius Gill. Champ. Fr. **1**: 687. 1878; *pl. 156.*

Phellinus igniarius Quél. Ench. 172. 1886.

This plant is one of the oldest fungi known, having been used from very early times for keeping fire, whence the name. It is also abundant and widely distributed, occurring on birch, willow, beech, maple, oak, poplar, apple and many other deciduous trees in various parts of the world. Fruit-bodies observed on apple, willow, aspen, birch, etc., in Sweden, agree perfectly with those growing in the New York forests; while the variations found in Europe are duplicated here, even to the abundance or scarcity of spines in the hymenium.

Specimens are to be found in all published exsiccati bearing upon this group. Among the large number of collections examined, the following may be mentioned: New York (Underwood), New Hampshire (Miss Minns), Ottawa, Canada (Macoun), New Jersey (Ellis), Virginia (Murrill), Kansas (Bartholomew), Indiana (Underwood), Colorado (Earle), Labrador (Waghorne), Maine (Ricker), New Mexico (Earle), Finland (Karsten), Sweden (Murrill), Thüringen (Underwood).

Two forms of *P. igniarius* are listed as distinct species in Saccardo's Sylloge, *i. e.*, *Fomes badius* Berk. and *Fomes nigricans* Fries. The former was collected in Arctic North America by Dr. Richardson and the type is at Kew. The specimen is 5 × 6 × 2.5 cm. and has three layers of tubes which, in the brief northern season, were forced to develop quickly and are therefore thinner-walled than in our forms. Berkeley himself doubted if the plants were sufficiently distinct from *P. igniarius*.

Fomes nigricans Fries, on the other hand, is decidedly different from typical *P. igniarius*, being neat and smooth and shining black, and rimose in two directions when old. Fries observed it on birch only. Persoon noticed it also frequently on old willows, and Underwood has collected fine specimens of the same form on beech in the New York mountains. While studying living plants on willow trees in Sweden, I found stages on the same tree connecting this variety with the typical form and am convinced that we are not here dealing with two distinct plants but with variations due to season, food supply, rapidity of growth, or some other physiological cause yet to be determined. Specimens have been examined from Finland (Karsten, Starbäck), Sweden (Romell, Murrill), Newfoundland (Waghorne), Greenland (Rostrup), New

Hampshire (Miss Minns) and New York (Underwood). Klotsch's collections from Scotland are *Polyporus fomentarius* L. of advanced age and indurated. This is the conception of *F. nigricans* at Berlin (see Sydow, Myc. Mar. No. 2604). At Kew, *F. nigricans* has been considered "rare the world over." A tiny specimen 2 × 3 × 2 cm. in the herbarium of Berkeley sent from Upsala presumably by Fries himself has the external appearance of *F. nigricans* (see Fries, Icon. *pl. 184*), but its size would indicate that it is *Poria levigata* Fries, in its pileate form, a state of this fungus not known to Fries and easily confused with depauperate forms of *F. nigricans.* The other specimens at Kew are all old hardened forms of *P. fomentarius* L.

2. **Pyropolyporus fulvus** (Scop.)

Boletus fulvus Scop. Fl. Carn. Ed. 2. **2**: 469. 1772.

Polyporus igniarius b. minor, subperpendicularis Fries, Syst. **1**: 375. 1821.

Polyporus fulvus Fries, Hym. Eur. 559; Icon. *pl. 184, f. 3.*

Fomes fulvus Gill. Champ. Fr. **1**: 687. 1878.

Phellinus fulvus Quél. Ench. Fung. 172. 1886.

Fries at first considered *Boletus pomaceus* Pers. synonymous with *B. fulvus* Scop., but later decided, and correctly so, that it is only a form of *P. igniarius* L. In Micheli's no. 9, p. 119, of his genus *Agaricum*, the two forms are confused, though his figure, *pl. 61*, ordo II, doubtless represents *P. fulvus* growing on *Prunus* and not *P. igniarius* growing on *Malus.* This confusion still exists in European herbaria and it is impossible to determine in them what is meant by *Polyporus fulvus* Fries. In the following description Scopoli very plainly characterizes the plant under discussion: "Totus fulvus; poris difformibus, non adeo profundis. Habitat in cerasis recens detruncatis. Junior integerrimus, adultus vero margine sinuatus. Fulvus color in margine et subtus evidentior. Poruli obsoleti, totum fungum subtus non semper occupant."

Pl. Crypt. France par Desmazières no. 5157. "Sur les pruniers et les cerisiers." Fung. Selec. Exsic. par Roumeguère No. 6963. "Forma *Cerasi*, sur un vieux cerisier." Trienti (Bresadola) on *Persica*, Eisenach and Thuringen (Underwood) on *Prunus*, Sweden (Murrill) on *Prunus*, and on *Prunus* both wild and cultivated, in America in Alabama (Underwood), Colorado (Bethel, Cameron, Crandall), Kansas (Bartholomew, Cragin), Missouri (?), Nebraska (Webber), Ohio (Lloyd), Tennessee (Schrenk).

This fungus is very uniform in habit and appearance both in Europe and America, where it occurs on various species of *Prunus* and its near allies. Although confused in literature with *Polyporus igniarius* L., it is very distinct and always easily recognized. In an orchard near Mauritzberg, Sweden, where *P. igniarius* was abundant on apple trees, *P. fulvus* was confined to the stumps and dead or dying trunks and branches of plum trees.

3. **Pyropolyporus crustosus** sp. nov.

An ungulate plant of medium size with brown tubes, ferruginous substance and smooth encrusted dark brown surface. Pileus woody, convex above, plane below, somewhat compressed ungulate, 7 × 12 × 5 cm.; surface glabrous, horny encrusted, dark brown, concentrically sulcate, marked with narrow black concentric lines; margin rounded, yellowish brown, sterile: context hard, concentrically banded, ferruginous, 2 cm. thick behind; tubes indistinctly stratified, 0.5–1 cm. long each season, 5–6 to a mm., drab-colored within, mouths polygonal, concolorous, edges thin, acute, entire: spores globose to ovoid, smooth, thin-walled, hyaline, 3.5–4 × 4 μ, hyphae darker, cystidia none.

Collected by Earle on a standing tree trunk at an altitude of 4,000 feet on Rose Hill, Jamaica, October, 1902.

4. **Pyropolyporus Calkinsii** sp. nov.

A large ungulate fungus glabrous and furrowed above and uniformly hard and fulvous within. Pileus very hard woody throughout, ungulate, 10 × 10 × 10 cm.; surface glabrous, dark brown to black, marked with rather shallow concentric furrows, crust thin, horny, never rimose; margin rounded, concolorous with the hymenium: context very hard woody, fulvous, 1 cm. thick; tubes in many indistinct layers, slender, minute, 7 to a mm., fulvous, mouths nearly circular, obtuse, entire: spores ovoid, hyaline, with thick, smooth, pale ferruginous wall, 3–5 × 5–7 μ, hyphae ferruginous, cystidia none.

This species occurs on living trees of live-oak in Florida, where it was collected in considerable quantity by Major W. W. Calkins during the winters of 1886 and 1887. Several specimens are in the herbarium of the New York Botanical Garden and a single specimen in the herbarium of the Division of Vegetable Pathology and Physiology of the U. S. Department of Agriculture.

5. **Pyropolyporus Everhartii** (Ell. & Gall.)

Mucronoporus Everhartii Ell. & Gall. Journ. Myc. **5**: 141–142. *pl. 12.* 1889.

Xanthochrous Everhartii Pat. Cat. Tun. 51. 1897.

The type of this fungus is in the herbarium of the New York Botanical Garden. Since its discovery on the living trunk of a scarlet oak in New Jersey, it has been collected in several localities on various species of oak and occasionally on beech. Before its separation as a distinct species it had been confused with *P. igniarius*, which it outwardly resembles in some particulars.

Collections: New York (Ellis, Mrs. Ellis, Murrill), New Jersey (Ellis, Ely), Canada (Dearness), Indiana (Gentry), Pennsylvania (Herbst) and Delaware (Commons, Ellis N. A. Fungi no. 3303).

6. **Pyropolyporus Robiniae** sp. nov.

A large fungus with dark rimose surface and tawny hymenium very common on *Robinia pseudacacia.* Pileus hard woody, dimidiate, ungulate to applanate, 5–25 × 5–50 × 2–12 cm.; surface velvety, smooth, soon becoming very rimose and roughened, fulvous to purplish-black, at length dull black, deeply and broadly concentrically sulcate; margin rounded, velvety, fulvous: context hard woody, concentrically banded, 1–3 cm. thick, fulvous; tubes stratose, 0.15–0.5 cm. long, 5 to a mm., fulvous, mouths subcircular, dissepiments entire, equalling tubes in thickness: spores subglobose, smooth, thin-walled, ferruginous, copious, 4–5 μ, cystidia none.

This fungus was one of the first to be noticed by collectors in this country, but has been unnamed until the present time. Schweinitz called it *Polyporus igniarius* and remarked that it was "frequent especially on *Robinia*"; Berkeley confused it with his *P. rimosus* described from Demerara and the Cape of Good Hope, and Cooke allayed Morgan's anxiety by assigning it most positively to the same category. To be sure, it resembles *P. rimosus* Berk. from Demerara, but the two plants are entirely distinct in appearance and shape and *P. rimosus* lacks the decided imbricated-rimose effect so characteristic of our plant. It was from the African plant, a different thing from *P. rimosus*, that the name *rimosus* must have been obtained. It is truly rimose like *R. Robiniae*, but differs decidedly from the latter in pore-structure and context, while the spores are larger and less globose. It would be quite remarkable if a group of plants from such widely separated localities did not show specific differences.

P. Robiniae is abundant in the southern United States on *Robinia* and extends with it as far north as Connecticut and west to Missouri and Texas. I have not as yet seen it upon any other host, but a plant recently collected by Earle in Jamaica on *Acacia emarginata*, nearly related to *Robinia*, seems not specifically distinct from it. When *Robinia* was introduced into France several centuries ago from Virginia this fungus must have been introduced with it, since it was collected there by F. Fautrey in November, 1891, growing on *Robinia.* The specimen is at Upsala and is labelled *P. igniarius.* Among the many collections examined from America, the following may be mentioned: Massachusetts (Underwood); New York (Underwood, Earle, Murrill); New Jersey (Ellis); Ohio (James, Morgan, Lloyd); West Virginia (Nuttall); Virginia (Miss V. W. Murrill); Alabama (Underwood, Atkinson, Earle).

A good account of the destructive effects of this plant is given by H. von Schrenk in Ann. Rep. Mo. Bot. Gard. **12**: 21–31. *pl. 1–3.* 1901.

7. **Pyropolyporus praerimosus** sp. nov.

A large ungulate plant with plane brown hymenium and a very rimose blackish surface. Pileus woody, rounded ungulate, 8–12 × 7–10 × 8–11 cm.; surface exceedingly rimose after the first year, broadly furrowed, the projecting ridges splitting away in age, very dark brown to black; margin obtuse, velvety, rusty to hoary: context corky to woody; concentrically banded, fulvous, 0.5 cm. or less thick; tubes indistinctly stratified, 1–2 cm. long each season, 3 to a mm., concolorous within and without with the context, mouths rounded to polygonal, ochraceous at first, edges rather thick, obtuse, becoming thin and often splitting in age: spores globose, smooth, deep ferruginous, 3–4 μ; spines ferruginous, 10–17 × 5–10 μ, largest at the base.

Collected by Earle, July, 1900, on *Quercus undulata* in the El Capitan Mountains, New Mexico, at an altitude of 7,000 feet. Related to *P. Everhartii* (Ell. & Gall.).

8. **Pyropolyporus Underwoodii** sp. nov.

A blackish ungulate plant of large size with furrowed rimose surface and long brown tubes. Pileus woody, broadly ungulate, attached by a narrow base, concave below, 7 × 14 × 11 cm.; surface many times concentrically furrowed, rimose, uniformly dark-brown to black; margin fulvous, acute or somewhat obtuse, velvety, undulate, marked with narrow zones: context hard, fulvous to dark brown, very thin, less than 0.5 cm.; tubes distinctly stratified, 0.5–1.5 cm. long each season, 3 to a mm., brown within, mouths darker, circular or polygonal, edges acute, entire: spores ellipsoidal, smooth, thin-walled, light yellowish-brown, $7 \times 9 \mu$, cystidia none.

Collected by Underwood and Griggs during the summer of 1901 near Coamo Springs, Porto Rico. The plant reminds one of *P. Robiniae*, but differs very widely in tube-structure, as well as in color, density and spore characters.

9. **Pyropolyporus juniperinus** (Schrenk)

Polyporus juniperinus Schrenk, U. S. Dept. Agr. Veg. Physiol. Bull. **21**: 9–16. *pl. 1–4.* 1900.

So far as I know, there are only two specimens of the fruiting stage of this plant in existence, one collected by Schrenk in Tennessee and the other by Miss Sadie F. Price in Kentucky. The latter specimen, the better developed of the two, was sent to the Underwood herbarium in 1895.

Both specimens were found upon *Juniperus Virginiana*, the wood of which is badly affected by its mycelium. The statement made by the author that the discovery of other specimens might prove this species to be only a form of *P. fomentarius* is entirely unnecessary, since such connection between two plants so distinct is beyond the range of possibility.

10. **Pyropolyporus Earlei** sp. nov.

A broadly ungulate plant with yellow pores, red context and a dark very rimose surface. Pileus woody, attached by a broad base, plane below, 6 × 13 × 17 cm.; surface concentrically sulcate, very rimose in older parts, fulvous to brownish-black, at length grayish-black from weathering; margin broad, obtuse, dark yellowish-orange, clothed with short dense tomentum of the same color: context woody, dark reddish-orange, concentrically banded with darker lines, very thin, 0.5 cm., rimose down to the tubes ; tubes unevenly stratified, 0.5–0.75 cm. long each season, 1–2 to a mm., ochraceous within during the first season, afterwards latericeous, mouths circular, ochraceous, edges obtuse, rather thin : spores ellipsoidal, smooth, thick-walled, ferruginous, 7–8 × 9 μ.

Collected by Earle in August, 1900, on a standing trunk of *Juniperus* in the El Capitan Mountains, New Mexico, at an attitude of 7,000 ft. It is closely related to *P. juniperinus* (Schrenk), but it is much more rimose, has larger pores and lacks the annual projecting margins of the older tube-layers so characteristic of that species.

11. **Pyropolyporus conchatus** (Pers.)

Boletus salicinus Pers. ; Gmel. Syst. **2** : 1437. 1791 ; Syn. 543. 1801. Not *B. salicinus* Bull. Herb. Fr. *pl. 433. f. 1.* 1789.

Boletus conchatus Pers. Obs. **1** : 24. 1796 ; Syn. 538. 1801.

Polyporus salicinus Fries, Syst. Myc. **1** : 376. 1821 ; Icon. *pl. 185. f. 2.*

Polyporus conchatus Fries, Syst. Myc. **1** : 376. 1821.

Fomes salicinus Gill. Champ. Fr. **1** : 684. 1878 ; Karst. Icon. 4, *f. 5.* 1883.

Phellinus salicinus Quél. Ench. 172. 1886.

Boletus salicinus Pers. and *Boletus conchatus* Pers. were different forms of the same plant. Most of the old willow stumps in Sweden are covered with it. On the sides of the stumps it is *B. salicinus* and farther up, where the pileus is reflexed, it is *B. conchatus.* This fungus is quite common in Europe and America on a variety of hosts. The following list includes only a few of the collections examined : Sydow, Myc. Mar. no. 3423 ; Ellis, N. A. Fungi no. 918 ; Romell, Fungi Suecici no. 12 ; England (Plowright), Sweden (Murrill), New York (Underwood, Ellis, Shear), Indiana (Underwood), Canada (Macoun), Ohio (Lloyd, Morgan), Pennsylvania (Rau).

12. **Pyropolyporus Haematoxyli** sp. nov.

A smooth applanate plant of considerable size with brownish tubes and honey-yellow context. Pileus woody, dimidiate, sessile, thickest behind, 12 × 14 × 4 cm.; surface glabrous, dark brown, shallowly concentrically sulcate, marked with numerous darker concentric lines ; margin fulvous, thin, rounded, slightly undulate : context corky to woody, indistinctly concentrically banded, honey-yellow, 1 cm. thick; tubes distinctly stratified, longer behind, 0.5–1 cm. long each season, 6 to a mm., dull brown, mouths polygonal, concolorous, edges obtuse, becoming thin; spores globose, rarely ovoid, thin-walled, smooth, hyaline, 3.5–5 μ, hyphae ferruginous, cystidia none.

Collected by Earle at the base of a living logwood tree in Paradise, Jamaica, November, 1902.

13. **Pyropolyporus Langloisii** sp. nov.

A large thin expanded fungus with brown hymenium and a brown or blackish surface. Pileus corky, fan-shaped, attached by a narrow base, often depressed behind, 8–13 × 10–25 × 0.3–1.5 cm.; surface at first anoderm, soft, clothed with brown tomentum, many times concentrically sulcate, at length glabrous, rough, indurate, black, marked with numerous shallow furrows; margin velvety, brown, thin, acute, undulate or slightly lobed: context soft to corky, indurate in age, deep brown, 0.2–0.5 cm. thick; tubes reviving, distinctly stratified, 0.2–0.5 cm. long each season, 9–8 to a mm., brown, mouths polygonal, concolorous, edges thin at maturity: spores globose, smooth, hyaline, 3 μ, cystidia none.

Collected in quantity several seasons in Louisiana by Langlois, exclusively on dead or dying hawthorn trees near the base of the trunk. Referred to *P. pectinatus* Kl., *P. senex* N. & M., *P. conchatus* Pers., and *P. Ribis* (Schum.) Fries by European mycologists, from all of which it is quite distinct, probably approaching nearest to the last. Several specimens from the various collections made by Langlois are in the Underwood herbarium and the herbarium of the New York Botanical Garden.

14. **Pyropolyporus Ribis** (Schum.)

Boletus Ribis Schum. Enum. Pl. Saell. **2**: 336. 1803.
Polyporus Ribis Fries, Syst. **1**: 375. 1821.
Polyporus ribesius Pers. Myc. Eur. **2**: 80. 1825.
Polyporus Ribis Fries; Sturm, Deuts. Fl. **3**: 137. *pl. 62.* 1837.
Fomes Ribis Gill. Champ. Fr. **1**: 685. 1878.

According to some authorities *P. Lonicerae* Weinm. and *P. Euonymi* Kalchb. are only forms of the above. Rabenhorst-Winter, Fungi Europaei, no. 2937; Roumeguère, Fungi Gallici, no. 3304; De Thümen, Myc. Univ., no. 509; Linhart, Fungi

Hung., no. 349; Krieger, Fungi Sax., no. 423; New York (Ellis); New Jersey (Geissman, Ell. &. Ev. N. A. Fungi no. 1693); Kansas (Bartholomew).

The usual host of this fungus is the red currant, but it is also found on other species of *Ribes* and occasionally upon other shrubs growing near by. Specimens from Bartholomew were collected on living stems of *Symphoricarpos occidentalis*, July 24, 1895; and it has also been reported as attacking rose-bushes.

15. **Pyropolyporus Yucatanensis** sp. nov.

A large blackish brown very rimose fungus with tawny tubes and substance. Pileus woody, dimidiate, applanate, thickest behind, 7–9 × 9–12 × 2–3 cm.; surface clothed at first with tawny tomentum, becoming very dark brown or black and uniformly tubercular and broken into small areas by numerous shallow concentric furrows and radial cracks; margin narrow, acute, velvety, fulvous: context hard, fulvous, 0.5 cm. thick; tubes rather indistinctly stratified, 0.25 cm. long each season, 7 to a mm., fulvous; mouths circular, punctate, edges thick, obtuse: spores globose or subglobose, smooth, pale yellowish brown, 3.5–5 μ, hyphae ferruginous, cystidia thick at the base, pointed, 17–35 μ.

Collected in Yucatan by Millspaugh and in Nicaragua by C. L. Smith.

16. **Pyropolyporus senex** (Nees & Mont.)

Polyporus senex Nees & Mont. Ann. Sci. Nat. II. **5**: 70–71. 1836.

Fomes senex Cooke, Grevillea, **13**: 118. 1885.

A number of specimens collected by C. L. Smith in Mexico and Nicaragua are in the New York Botanical Garden herbarium. Dr. Patouillard says they are typical *P. senex*. They are larger, thicker and more woody than plants from Florida and Louisiana that have been called *P. senex*.

17. **Pyropolyporus linteus** (B. & C.)

Polyporus linteus B. &. C. Proc. Am. Acad. Arts & Sci. **4**: 122. 1860.

Fomes linteus Cooke, Grevillea, **14**: 20. 1885.

The type specimens were collected on dead bark in Nicaragua. Plants collected in Nicaragua by C. L. Smith agree with the types in all important particulars. The same species from Cuba is labelled *P. pectinatus* Kl. at Kew, though the latter plant does not, to my knowledge, occur in North America.

18. **Pyropolyporus Jamaicensis** sp. nov.

A rather small fan-shaped plant, the upper layers of which are dead and much cracked and roughened while the layers added below are smaller each succeeding year. Pileus woody, applanate, much thicker behind, 8 × 13 × 0.5–5 cm.; surface uneven, radiately rimose, dark brown to black; margin ferruginous, velvety, acute, becoming black, spreading and lobed, projecting 1–2 cm. beyond the new layers: context woody, fulvous, 0.5–1 cm. thick; tubes stratified, separated by thin annual layers of context, 0.2–0.7 cm. long each season, 7 to a mm., fulvous within, mouths rounded or polygonal, hoary when young, edges thin, acute, entire: spores globose or subglobose, thin-walled, smooth, pale golden-yellow (probably darker in age), 5–7 μ.

Collected by Earle, at Port Antonio, Jamaica, November, 1902, on an old stump of *Psidium*. The spores of the present season appear immature.

SPECIES INQUIRENDAE

In this list is included not only species at present unknown, but also plants described by foreign authors which have not been seen or have been as yet only slightly studied by the writer. *Polyporus extensus* Lév., *P. elatus* Lév., *P. Nicaraguensis* B. & C., *P. sarcitus* Fries, *P. sclerodes* Berk., *P. scleromyces* B. & C., *P. sordidus* Lév., *P. subflexibilis* B. & C., *P. Baccharidis* Pat., *Ganoderma Mexicanum* Pat., *Xanthochrous igniarioides* Pat.

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TORREY BOTANICAL CLUB

MARCH, 1903

Studies in Plant Hybrids: The Spermatogenesis of Hybrid Cotton

By William Austin Cannon

(With Plates 7 and 8)

Introduction

Perhaps the first suggestion that we have as to the possibility of crossing two or more less distantly related plants was given by Camerarius * in his letter to Valentini on the sexuality of plants. This was in the year 1694. In this letter Camerarius speculates as to the effect of crossing the hemp (*Cannabis*) and the hop (*Humulus*), wondering whether the posterity of the form used as the mother would by this cause be altered. He did not make the cross, and in fact it was not until 1760 that the first plant hybrid which was of use to science was made. In that year Kölreuter,† perhaps the greatest as he was the first of hybridizers, crossed *Nicotiana paniculata* ♂ and *N. rustica* ♀ and obtained fertile offspring, and thus began successfully the experimentation which he carried on with so great results for several decades.

The first plant hybrid thus empirically formed served a good purpose by providing incontestable evidence upon certain of the leading biological questions of the day. It fortunately was of the intermediate type, and thus the fact that both parents contributed equally to the formation of the hybrid offspring demonstrated at once the falsity of the evolution or preformation hypothesis, gave

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* Camerarius, Ueber das Geschlecht der Pflanzen, translated from the Latin "De sexu plantarum epistola." (Ostwald's Klassiker der exakten Wissenschaften, **105** : 49. 1899.)

† Kölreuter, Vorläufige Nachricht von einigen das Geschlecht der Pflanzen. (Ostwald's Klassiker der exakten Wissenschaften, **41** : 30. 1893.)

[The preceding number of the Bulletin, Vol. 30, No. 2, for Febuary, 1903 (30: 75–132), was issued 28 F 1903.]

a strong support to the idea of sex in plants, and also pointed the way to the true conception of fertilization.

In addition Kölreuter, in the course of his long career as a hybridizer, arrived at other results that were of almost equal importance. For instance, he first pointed out the meaning of the visits of insects to flowers, and thus formed the basis for Sprengel's subsequent work, and he first showed the significance of nectar in this connection.* Kölreuter also introduced the "modern" methods in experimental research, as a single illustration taken from many will suffice to show. He had the mistaken idea that the part of the pollen necessary to insure fertilization was the fluid which he had observed about it and which he supposed originated in the interior of the grain and oozed out through the pores. He therefore was interested to learn how many grains were required to effect fecundation. To ascertain this he counted the grains in a flower and artificially pollinated with a varying but a known number. In *Hibiscus Trionum* he counted 4,863 grains, and found that only 50–60 were necessary to fructify more than 30 ovules. In *Mirabilis Jalapa* and *M. longiflora* two or three, or only one were required to fertilize the single ovule.

Kölreuter recognized all of the important characteristics of plant hybrids.† He learned that species-hybrids were as a rule intermediate and uniform, whichever race provided the male or female parent. He observed the fruitfulness of variety-hybrids, the sterility or lessened fruitfulness of those between species, the stronger growth of many hybrids and other phenomena. In his experiments Kölreuter used mainly the following genera: *Aquilegia*, *Matthiola*, *Dianthus*, *Melandrium*, *Linum*, *Malva*, *Lavatera*, *Lobelia*, *Nicotiana*, *Datura*, *Lycium*, *Verbascum*, *Digitalis* and *Mirabilis*.

About the time that Kölreuter was engaged in the experimental study which gave such remarkable results, Linné, ignoring that scientist's work, put forward theories in which hybrids played a prominent rôle. And this was done with hardly any experimental basis for his ideas. I refer to Linné's hypotheses regarding the origin of genera and species. According to Sachs (*l. c.*

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* Sachs, Geschichte der Botanik, 440. 1875.

† Focke, Die Pflanzen-Mischlinge, 431. 1881.

114) the doctrine is in brief this, in the first place classes were created, by the subsequent mixing of the individuals of the different classes genera arose, and finally by the crossing of these genera species were differentiated.

It was not long however before some practical tests were made of the relation of the constancy of species to the possibility of deriving fertile hybrids by crossing them. Apparently without an adequate reason for his belief, Sprengel thought that crosses between distinct natural species might be fertile, and he accordingly is pleased to discover means by which plants may resist hybridizing, as for instance the difference in season of the maturation of the reproductive organs. This is considered by him as a miraculous adaptation for the preservation of the purity of the species.

The relation of Kölreuter's results and methods to the science of his time is so well given by Sachs that I shall quote a paragraph direct (*l. c.* 446): " Der allgemein theoretische Werth von Koelreuter's künstlichen Pflanzenbastarden ist gar nicht hoch genug anzuschlagen; die Vermischung der Eigenschaften der väterlichen und mütterlichen Form war der stärkste Beweis gegen die Evolutionstheorie und liess gleichzeitig einen tiefen Blick in das wahre Wesen der sexuellen Vereinigung thun. Auch ging aus Koelreuter's zahlreichen Untersuchungen sofort hervor, dass nur ganz nahe verwandte Pflanzen und auch diese nicht immer einer geschlechtlichen Vereinigung fähig sind, wodurch die vagen Vorstellungen Linné's für jeden Urtheilsfähigen sofort beseitigt wurden, wenn es auch immerhin noch lange dauerte, bis die Wissenschaft alle Vortheile aus Koelreuter's Untersuchungen zog. Die Pflanzensammler aus der Linné'schen Schule ebenso, wie die eigentlichen Systematiker am Ende des vorigen Jahrhunderts, hatten kein Verständniss für derartige Leistungen, ja Koelreuter's Ergebnissen zum Trotz, verbreiteten sich in der botanischen Literatur später unrichtige Vorstellungen über Bastarde und ihre Fähigkeit sich fortzupflanzen; den Gläubigen der Constanzlehre konnten die Bastarde ohnehin nur unbequem sein, sie störten ihnen die Reinlichkeit des Systems und passten zudem nicht recht zu der Annahme, dass jede Species eine ' Idee ' repräsentire."

Whether hybrids between parents of different species are always sterile, and those between varieties always fertile, soon became a question of great importance, since by this means it was hoped that a distinction between varieties and species might be had. Early in the nineteenth century the question was taken up by English and later by French botanists and since the facts were not well known the bearing of them on the question under discussion was also much in dispute. In England, Herbert * and Knight † discussed the relative fertility of species- and variety-hybrids, the latter author holding that hybrids from parents of different species are always sterile, but on the other hand that the varietal hybrids are always fertile. From the results of his experiments and study Knight concluded also that fruitful hybrids indicate that the parents are not distinct species, but varieties of the same species. Herbert on the contrary found that hybrids between different species are not seldom fertile. As to the significance of this he does not appear to think the parents were of the same species, but rather (*l. c.* 16) that they "have branched out from one common stock since the creation of the world." He further says: "If it be admitted, that diversity of species could have been produced by variations of soil, temperature, or humidity, it will be readily understood that such diversity might have been further multiplied by hybrid intermixture, as the species were brought together by the natural progress of their diffusion."

It will not be necessary for the purposes of this paper to enter more into the details of this phase of the "constancy of species" doctrine. The ground that Knight and Herbert threshed over in England was gone over again later (1862) in France by Naudin and Godron.‡ Finally, Darwin § has pointed out that not only is the fertility or sterility of a hybrid no criterion of the relationship of the parents, but that the hybrid may even be more fruitful than either pure parent.

Focke (*l. c.* 443) says that up to the time of Nägeli (1865) the knowledge of hybrids was unconnected and fragmentary, and that this author united and made coherent the results of the earlier hybridizers. Especially he drew consistent conclusions from the facts gathered together by Gärtner. The general conception of hybrids held at the present is based on Nägeli's writings. He noted the tendency of hybrids to vary, and to revert, and he showed the value of the reciprocal cross, and, finally, he formulated the laws governing the action of hydrids. He also observed the behavior of hybrids in the second and later generations when they were inbred, although the significance of this was of course not appreciated by him.

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* Herbert, On the Production of Hybrid Vegetables. Trans. Hort. Soc. Lond. 4: 15. 1820.

† Knight, Observations on Hybrids. Trans. Hort. Soc. Lond. 4: 367. 1821.

‡ Focke, Die Pflanzen-Mischlinge, 441. 1881.

§ Darwin, On the Origin of Species, Am. ed., 235. 1883.

At the time when the work of Nägeli was being published, that of Gregor Mendel * had been recently presented to the society at Brünn. His main theme was to account for the behavior of hybrids in the second and later generations. It will not be necessary in this place to present a full account of Mendel's laws because since their rediscovery by de Vries,† Correns,‡ and Tschermak § they have been put out unabridged both in their original form || and in English translation,¶ and have been explained by several writers. ** For convenience of reference I shall however give a brief outline of Mendel's results and conclusions taken mainly from my previous paper.††

When one pure form (A) is crossed with another pure form (a) the hybrid of the primary cross shows the A characters only. When, however, the hybrid plants of this generation are fertilized

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* Mendel, Versuche über Pflanzen-Hybriden. Abh. Naturf. Ver. Brünn, **4**: 3. 1866.

† De Vries, Das Spaltungsgesetz der Bastarde. Ber. Deuts. Bot. Gesells. **18**: 83. 1900; Ueber erbungleiche Kreuzungen. Ber. Deuts. Bot. Gesells. **18**: 435. 1900; Sur les unités des caractères spécifiques et leur application a l'étude des hybrides. Rev. Gèn. Bot. **12**: 257. 1900.

‡ Correns, G. Mendel's Regel über das Verhalten der Nachkommenschaft der Rassenbastarde. Ber. Deuts. Bot. Ges. **18**: 158. 1900; Gregor Mendel's "Versuche über Pflanzen-Hybriden" und die Bestätigung ihrer Ergebnisse durch die neuesten Untersuchungen. Bot. Zeit. **58**^{2}: 229. 1900.

§ Tschermak, Ueber künstliche Kreuzung bei *Pisum sativum*. Zeitschr. Landw. Versuchswesen Oesterr. **5**: 465. 1900; Ber. Deuts. Bot. Gesells. **18**: 232. 1900.

|| Ostwald's Klassiker der exakten Wissenschaften, No. **121**. 1901.

¶ Jour. Roy. Hort. Soc. Lond. **26**: 1. Au 1901.

** Bateson & Saunders, Experimental Studies in the Physiology of Heredity. Rep. Evolution Committee Roy. Soc., Report 1. 1902; Emerson, Agric. Exp. Sta. Neb. Rep. **15**: 30. 1902; Spillman, Science, II. **16**: 709. 1902; Pop. Sci. Month. **62**: 269. Ja 1903.

†† Cannon, A Cytological Basis for the Mendelian Laws. Bull. Torrey Club, **29**: 657. D 1902

among themselves and produce offspring the *a* characters are seen, and in a definite proportion to the form bearing the *A* characters. These constitute the hybrids of the second generation. If now the hybrids of the second generation are fertilized in such a manner that plants with *a* characters are crossed with those bearing the same characters, and likewise plants bearing *A* characters with forms like themselves, the resulting hybrids will behave in a manner characteristic of the respective cross. That is (1) the plants with *a* characters will be found to transmit those characters only, *i. e.* they are "fixed"; and (2) when the plants with *A* characters are fertilized with other plants bearing the same characters, that is to say, if inbred, two sorts of hybrids will result: one portion will bear only the *A* characters, which may be demonstrated by breeding as before, and one portion, apparently also with *A* characters only, will be found to vary just as the hybrids of the primary cross varied, *i. e.* this will be really mixed or hybrid. This general scheme may be better understood if tabulated as follows:

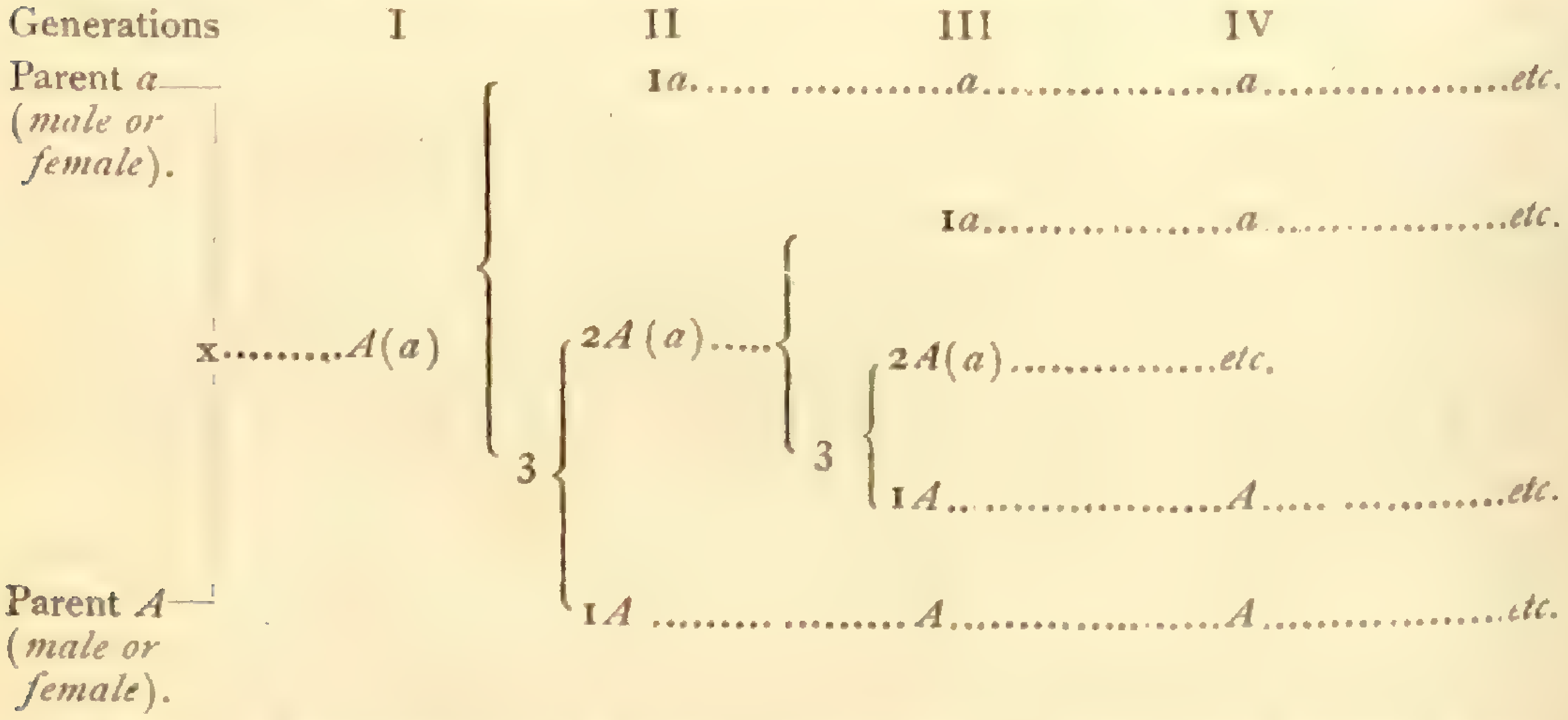
Generations
I
II
III
IV
Parent *a*
(*male or female*).
x........*A*(*a*)
1*a*.......*a*.......*a*.......*etc.*
1*a*.......*a*.......*etc.*
2*A*(*a*)
2*A*(*a*).......*etc.*
3
3
1*A*.......*A*.......*etc.*
1*A*.......*A*.......*A*.......*etc.*
Parent *A*
(*male or female*).

FIG. 1. Explanation: *A*, dominant character; *a*, recessive character; *A*(*a*), a hybrid having both characters of which (*a*) is masked by *A*.

Not only do the hybrids vary thus in a regular manner, but there is also a definite proportion of recessives (*a*), and dominants (*A*), as the table indicates. That is, referring to the table, in the second generation one fourth of the offspring is recessive (*a*), and three fourths apparently dominant (*A*), but really composed of two sorts (*A*(*a*)) one third of these being dominant (*A*), two thirds mixed (*A* (*a*)). The latter continue in the succeeding generation to vary just as the hybrids of the primary cross varied, one fourth of their offspring being recessive, one fourth dominant and one half mixed.

The regularity in the variation as just described in the second and later generations is accounted for by supposing that the hybrids of the first generation organize germ-cells which are of pure descent, and that these unite in fertilization according to the laws of chance. Taking a specific case by way of illustration, we can imagine the following to take place, when the sex-cells of say the second generation hybrids ($A(a)$) meet each other in fecundation. The pollen, which is of pure descent, unites with the egg, which also is of pure descent, and the chances of union may be thus expressed: $A\ A$; $A\ a$; $a\ A$; $a\ a$. So that it happens, since the anther forms two sorts of germ-cells and the ovaries also two sorts, that in this way one half of the hybrids of say the third generation will be of mixed descent, and one half pure, the latter being equally recessive and dominant. The results, as calculated by the laws of chance, are thus seen to be precisely the same as what is found empirically to occur.

Such may perhaps be considered the more essential facts and conclusions of the discovery of Mendel, and upon them are based the two so-called "laws" of Mendel, namely, the law of dominance and that of the splitting of the hybrid race.

Mendel gives also, and in much detail, the results when the pure parents of hybrids are separated by more than one character, as, for instance, by *two* or *three*. But his experiments are too extensive to present here and I can not do better than to quote from the account of them by Bateson (*l. c.* 9). "In both sets of experiments the numbers of individuals and their constitution * * * were consistent with the hypothesis arrived at in the case of varieties differing in respect of one character, namely, that each male and female cell of the cross-bred is pure in respect of one character of each pair of characters, and is capable of transmitting this character to the exclusion of the opposite character; that the reproductive cells are, in the cross-breds, of as many kinds as there are possible combinations of pure characters (taken two or three together, as the case may be); and, finally, that each kind is represented in the cross-breds on the average in equal numbers."

In considering the probable bearing of Mendel's discovery on the biological sciences I can do no better than to quote at some length from Bateson's recent report, but of course I shall not attempt to present a summary of all of this author's conclusions.

Bateson says (*l. c.* 125): "With the discovery of the Mendelian principle the problem of evolution passes into a new phase. It is scarcely possible to overrate the importance of this discovery. Every conception of biology which involves a knowledge of the physiology of reproduction must feel the influence of the new facts, and, in their light, previous ideas of heredity and variation, the nature of specific differences, and all that depends on those ideas must be reconsidered, and in a great measure modified."

So much for the scope of the Mendelian principle. Bateson then cites specific examples, well known to breeders and scientists, which have hitherto been puzzling enough but which are apparently well explained by the discoveries of Mendel. Among these may be mentioned (1) the skipping of a generation, (2) the appearance in a pure strain of "rogues," and (3) the inability of breeders to fix by selection certain forms. The first is an integral part of the Mendelian conception and therefore need not be spoken of further here. The "rogues" which appear in apparently pure strains are supposed to be recessives, while in such instances the characters desirable for fixation are the dominant ones. And the last case will be best explained by the author himself. At page 131 he says: "It has long been known to breeders that certain forms cannot be fixed by selection indefinitely continued. In other words, though they produce offspring like themselves, they have also a large number which do not resemble them.

"A case of this kind is seen in breeding crested canaries. The kind of crest desired for exhibition can, according to canary-fanciers, be produced most easily by mating crested birds with non-crested, or plain heads as they are called. If it is supposed that the crested character is usually dominant, we have a simple explanation. When crested birds are bred together a number of birds are produced whose crests are coarse and stand up and others without crests. The latter are the recessives; the former we may suppose to be the pure dominants. What the fancier wants is a crest composed of long feathers lying evenly down over the head.

These may be the heterozygotes,* and consequently cannot breed true or be fixed by selection. Such birds bred together, give many plain heads and birds with coarse crests."

Bateson also speaks of the relation of other phenomena to the Mendelian conception, such as *continuous* or *discontinuous variation, prepotency and the determination of sex*, but it will not be necessary in this connection to quote more at length.

Although the foregoing account of the relation of the history of hybridizing to that of the other biological sciences is from necessity an outline only, I think it can be seen that hybridization has at various times played an important rôle, and occasionally a definitive one, in aiding the solution of perplexing biological problems.

THE RESULTS OF EXPERIMENTAL HYBRIDIZATION

Florists and gardeners have long employed the crossing of closely related plants † as a means of obtaining new and useful races and it is without doubt largely due to them that so much is at present known about the behavior of plant hybrids. To the practical as well as to the theoretical hybridizer the manner of the transmission of the parental characters, the fertility or sterility of the hybrid, and the variation of the hybrid race are of the highest importance.

The variation in hybrids is dependent on the manner in which they reproduce parental characters. These characters may be blended in the hybrid, they may be associated in a variety of ways, or the hybrid may recapitulate in detail the characters of either parent. Moreover, the hybrid of the primary cross may show variation to a different degree from that of the second, or of the later generations. The phenemona in the first generation are the essentials of what is commonly understood by the term hybrid, and as such are described in all literature of the subject; the behavior of the hybrids in the second and following generations, although of the greatest importance, has been little studied.

---

* By "heterozygote" is evidently meant a hybrid, apparently only dominant, but really with both opposing characters ("allelomorphs" of Bateson, "Paarlings" of Correns) united to form the "zygote"; in the "homozygotes," on the other hand the characters of the pair are alike.

† Compare Richard Bradley's "New Improvements of Planting and Gardening, both Philosophical and Practical," p. 16. London, 1726.

The variations of the hybrids are many and complex, and it would be impossible as well as unnecessary for the purposes of this paper to attempt to present anything like a full account of the subject, much less to give a very complete list of hybrids to illustrate the variations. What I shall give is largely drawn from the work of Focke already quoted, and a shorter one by Swingle and Webber,* although I shall not confine myself wholly to these sources.

The characters of the parents may be perfectly blended in the hybrid so that neither parent is "favored" (*Datura Metel* × *D. meteloides*, *Geum intermedium* †). In other cases the hybrid may not be intermediate but may exhibit all grades of the characters by which the parents are distinguished from each other (*Abutilon* hybrids), even reproducing in great detail either parent (*Hieracium* hybrids, those of the maize, *Cytisus Adami* ‡ and the pods of some hybrid peas, etc. §). Or the hybrid may show the characters of either parent without intermediate grades (strawberry hybrids). The foregoing refers to the behavior of the hybrids of the first generation, or those of the primary cross; in the second generation the variations are equally well marked.

In the second generation the hybrids that were intermediate and uniform in the first one may remain so (*Geum intermedium*, Burbank's raspberry-dewberry hybrid). Or such hybrids may vary (*Nicotiana rustica* × *N. paniculata*). Hybrids which present variations in the first generation tend to become more variable in the second and third generations. Those that in the first generation resembled either parent may continue to revert in a similar manner (strawberry hybrids), or an intermediate condition may be present in addition to the extreme racial forms (*Datura Metel* × *D. meteloides*).

Another phase of variation is found in the changes that a hybrid may exhibit in the course of its life, or ontogeny. In the earlier stages it may show the characters of one parent, and in the later ones those of the other. For example, hybrid *Tropeolum* which was intermediate at the beginning of the season, reverted later to the mother form with intermediate grades * ; in spring the leaves of hybrid *Cistus* and *Populus* may show characters of one of the parents, and in the autumn those of the other; or in other hybrids (*Melandrium album* × *M. rubrum*, *Epilobium roseum* × *E. montanum*) the flowers may change during the blossoming from the characters of one parent to those of the other; or this may take place in different years (*Bletia crispa* × *B. cinnabarina*, *Galium cinereum* × *G. verum*).

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* Swingle & Webber, Hybrids and their Utilization in Plant Breeding. Yearb. U. S. Dep. Agric. 1897: 383. 1898.

† Salter, On the Fertility of certain Hybrids. Phytologist, 4: 737. 1852.

‡ Farmer. Ann. Bot. 11: 538. 1897.

§ Tschermak, Weitere Beiträge über Verschiedenwerthigkeit der Merkmale bei Kreuzung von Erbsen und Bohnen. Ber. Deuts. Bot. Gesells. 19: 35. 1901.

In another sort of hybrids the parental characters may reappear side by side — these are the so-called "mosaic" hybrids. They usually result from the union of closely related parents. As a single example of mosaic plant hybrids, that produced by crossing *Rhododendron Rhodora* × *R. calendulaceum* may be cited. In this case the flower has the colors of the flowers of both parents, and these are reproduced unchanged and stand side by side. Darwin † gives an example of an interesting mosaic animal hybrid. He says "the hairless condition of the Paraguay dog is either perfectly or not at all transmitted to its mongrel offspring; but I have seen one partial exception in a dog of this parentage which had part of its skin hairy, and part naked; the parts being distinctly separated as in a piebald animal."

Occasionally the hybrids are invariable and come true to seed. Such a one is the *Oenothera* hybrid of de Vries,‡ formed by the union of *O. rubrinervis* and *O. nanella*, which has been grown several generations without reversion. Another case may be mentioned out of many, namely, that of the *Geum* hybrid already referred to. This plant is a natural hybrid in certain parts of England, and was formerly supposed to be a distinct species. Salter § reproduced the hybrid by crossing *G. rivale* and *G. urbanum*. All of these hybrids were uniform and intermediate, and came true to seed for many generations.

Still another class of inheritable characteristics may well be mentioned; I refer to the transmission of such characters as hardiness, or the reverse of this, the ability to withstand warmer climates. Of the former the hybrid between *Montbretia Pottsii* and *Tritonia aurea* is given by Swingle and Webber (*l. c.* 414), who also present the Le Conte and Kieffer pears as examples of the latter. These writers say (*l. c.* 416) that the "adaptability of the Kieffer and Le Conte pears to growth in warmer climates is doubtless derived from the mother," that is, the Chinese sand pear. The ability to resist diseases is another transmissible character. The French varieties of grapes have been made resistant to phylloxera by crossing with hardy American forms. The hybrid may also be different from either parent in qualities analogous to the above. For example, it may be more vigorous than either parent, or may attain a larger size. Such variations are found in the offspring of closely related plants. The walnut hybrid of Burbank (*Juglans regia* × *J. Californica*), mentioned by Swingle and Webber, "grows twice as fast as the combined growth of both parents. * * * The wood is very compact, with lustrous, silky grain, taking a beautiful polish, and as the annual layers of growth are an inch or more in thickness and the medullary rays prominent, the effect is unique."

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* Darwin, Animals and Plants Under Domestication, Am. ed., 1 : 470. 1868.

† Darwin, *l. c.* 2 : 117.

‡ De Vries, Die Mutationstheorie, 1 : 461. 1901.

§ Salter, *l. c.* 739.

We shall take up now briefly the relative sterility or fertility of hybrids, and what is closely associated with it, the limits of a cross.

Focke * says that, as a general rule, "je näher die morphologische und systematische Verwandtschaft der Stammformen ist, um so weniger pflegt das geschlechliche Fortpflanzungsvermögen der Mischlinge von der Norm abzuweichen; je ferner die Stammformen einander stehen, um so mehr zeigt sich durchschnittlich die Fruchtbarkeit der Mischlinge geschwächt."

Increased or total sterility is brought about in various ways, as for example, there may be no pollen and no good seeds produced, or there may be a smaller amount of either than in the pure parents. Focke says that no peculiarity of hybrids has attracted so much attention as the lessening of the power of sexual reproduction, and it has been pointed out how important this fact was formerly supposed to be in its relation to the limits of species and varieties. Darwin (*l. c.* **2**: 218) says that "the sterility of distinct species * * * and that of their hybrid offspring, graduates, by an almost infinite number of steps, from zero * * * up to complete fertility." Focke (*l. c.* 477) gives genera or families that illustrate the variation of plants as regards the fertility of their hybrid offspring. The hybrids of *Papaver*, *Viola*, *Verbascum* and *Digitalis* are slightly fruitful; those of *Anemone*, *Nicotiana*, *Mentha*, *Crinum*, the Cucurbitaceae and the Passifloraceae are often so; while in the following there are more fruitful than unfruitful hybrids: *Aquilegia*, *Dianthus*, *Pelargonium*, *Geum*, *Epilobium*, *Fuchsia*, *Cotyledon*, *Begonia*, *Cirsium*, *Erica*, *Rhododendron*, *Calceolaria*, *Quercus*, *Salix*, *Gladiolus*, *Hippeastrum*, the Gesneriaceae and the Orchidaceae. While the crosses between distinct species produce hybrid progeny that are variable as regards the quality of fertility, it seems that nearly all hybrids from plants more distantly related are wholly sterile. As an example of fertile bigeneric hybrids, however, the well-known Aegilops wheat may be cited; but this rule is apparently invariable as regards the few that have parents from different families.

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* Focke, Die Pflanzen-Mischlinge, 489. 1881.

When the abnormal condition of the male reproductive organs causes sterility, as is likely to be the case, this infertility may be brought about by a variety of structural causes. The anthers may contain pollen but dehiscence may not take place to allow the pollen means of escaping, or pollen may be entirely wanting. In speaking of this question Focke (*l. c.* 478) says that "in andern Fällen besteht der Blüthenstaub aus kleinen pulverigen bei Anfeuchtung nicht quellenden Körnern von ungleicher Form und Grösse, denen gewönlich einzelne wohlgebildete keimfähige Pollenzellen beigemischt sind." The conclusion in this case is that the abnormal pollen is the cause of sterility and that the normal only is functional. Also, according to Duchartre * Naudin made the observation that the relative fertility of hybrids was *en rapport* with the number of normal pollen-grains formed in the hybrid.

Another and much less usual cause of sterility is found in the apparent incapacity of the female organs to be fecundated, but in many such cases it may be that there is no morphological defect in the ovule. Such a hybrid may sometimes, or usually, be fruitful if fertilized by another plant of the same strain, or by one of the parents, and it is occasionally fertile when self-fertilized, or when pollinated by a plant of the same sort (*Rubus caesius* × *R. Idaeus*).

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* Duchartre. Ann. Sci. Nat. Bot. IV. 19: 129. 1863.

Besides the forms of sterility that result from imperfect sexual organs an infertile condition may also result from other causes. For instance, in unisexual flowers, the male buds may fall away, as in the Cucurbitaceae and the Bignoniaceae, or in some hybrids, *Pelargonium* and *Digitalis* (*D. lutea* × *D. purpurea tubiflora* Lindl.), the anthers may be so transformed that the flowers are hermaphrodite. Finally, sterility may manifest itself in the reluctance with which hybrids produce flowers, as in those of *Rhododendron*, *Epilobium*, *Cereus* and *Hymenocallis*, but Focke (*l. c.* 477) says that these are rare exceptions, since as a rule hybrids flower earlier and more profusely than pure species.

As to the relation between vegetative vigor and relative fruitfulness of hybrids, Swingle and Webber (*l. c.* 412) say that in some cases "the increase in vegetative vigor secured by crossing distinct species is at the expense of fertility, but this is by no means true in all. Focke says that 'it was formerly thought that the diminished sexual fruitfulness is compensated by a greater vegetative luxuriance, a statement the untenableness of which, as Gärtner showed, is most plainly demonstrated by the fact that many of the most fruitful crosses (*Datura*, *Mirabilis*) are also distinguished by a most gigantic growth.' On this subject Fritz Müller also says: 'So far as my experience goes, the hybrids which grow the most luxuriantly are generally the most fruitful.'" Although other instances illustrating this principle might be given it will suffice, I think, to mention the remarkable walnut hybrid which Burbank succeeded in producing from the English form and the California one. This was referred to above (page 144). In this hybrid not only is there a great vigor of growth but the fruit is also unusually large and probably very abundant.

There appears to be no relation between the ease of making a cross and the fertility of the resulting form, but as a rule, the nearer the relationship of the parental forms the more readily will they be crossed. Strasburger,* in commenting on this subject, says: "Manche Familien neigen leichter dazu (Solanaceen, Caryophyllaceen, Irideen u. s. w.), andere bilden nur schwierig oder

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* Strasburger, Lehrbuch der Botanik, Ed. 5, 248. 1902.

überhaupt keine Bastarde (Papilionaceen, Coniferen, Urticaceen, Convolvulaceen u. s. w.). Dasselbe abweichende Verhalten findet sich unter verwandten Gattungen und Arten vor. Weinreben, Weiden, *Dianthus*-Arten sind leicht, *Silene*-Arten schwer, die von *Nicotiana*, *Verbascum*, *Geum* leicht, die Arten von *Solanum*, *Linaria*, *Potentilla* dagegen schwer unter einander zu bastardiren. Eine Hybridisirung von nahe verwandten Arten will oft nicht gelingen (z. B. Apfel- und Birnbaum), dagegen lassen sich Pfirsich mit Mandel, ja sogar Species der verschiedenen Gattungen *Lychnis* und *Silene*, *Rhododendron* und *Azalea*, *Aegilops* und *Triticum* kreuzen, je nach ihrer 'sexuellen Affinität.'"

The suggestion of Strasburger that crosses between mosses and ferns cannot take place because of the difference in the chemical nature of the fluids attractive to the spermatozoids of the two forms, may be a fruitful one when applied to other plants that are difficult or impossible to cross. That is, the substance that attracts spermatozoids, or the pollen-tube, may vary with the plant, and instead of attracting may even repel them. So far as I know the course of the pollen-tube in plants that are nearly enough related for crossing, but which refuse to be crossed, has not been traced, and it is possible that here may be found one reason why certain reciprocal crosses will not take place, why nearly related plants may sometimes not be crossed, and also why one sort of pollen is "prepotent" over another sort. That the pollen-tube responds to such stimulus in the course of its wanderings most sensitively is well shown by Lloyd's account * of its behavior in *Diodia* and *Richardsonia*. There may be other factors, as Vernon † has found that the relative maturity of the sexual elements in some echinoderms is of great importance when the number of successful crosses, and even the effect of each parent on the offspring, are concerned.

While it is perfectly true that only nearly related forms as a rule may be crossed, there are many instances where hybrids have been made whose parents were generically and even more remotely separated. These, as was mentioned above, are usually wholly sterile. A few such hybrids may be mentioned here.

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* Lloyd. Mem. Torrey Club, **8**: 88. 1902.

† Vernon, Hybrid Echinoid Larvae. Proc. Roy. Soc. **63**: 228. 1898.

Gladiolus blandus Sol. of the lily family was fertilized with pollen of *Hippeastrum* sp. and seeds were formed that produced four hybrids, all of which were presumably sterile (Focke, *l. c.* 388). The same author says that *Digitalis ambigua* of the Scrophulariaceae was crossed by Campbell with pollen of *Sinningia speciosa* of the Gloxiniaceae, and of the seeds that were formed only one produced a plant, and that one was sterile. The limits for any cross are thus set by related families, but as has already been shown the limits bounded by the fertility of the offspring are much narrower.

STUDIES OF THE SPERMATOGENESIS AND STRUCTURE OF HYBRIDS

A few morphological studies of hybrids have been made which may now be briefly referred to. I shall speak first of the work on the gametogenesis of hybrids.

Juel * studied the spermatogenesis of *Syringa Rothomagensis*, and as a leading result found that the maturation mitoses were irregular and abnormal, although in some respects certain of the mitoses reported by him approach the usual or normal type. The abnormalities in the tetrad formation are classified and summarized by him as follows:

A. In früheren Entwickelungsstadien auftretend:
  1. Verkümmern der Pollenmutterzellen beim Eintritt des Spiremstadiums;
  2. Durchschnürung des Kernes der Pollenmutterzelle im Spiremstadium;

B. Bei der Tetradentheilung auftretend:
  3. Durchschnürung der Kerne;
  4. Erste Kerntheilung indirect, aber in Bezug auf das Verhalten der Chromosomen abnorm;
  5. Achromatische Kernfigur abnorm;
  6. Ein Theil des Chromatins im Cytoplasma zerstreut;

C. An den Tetraden beobachtet:
  7. Ueberzählige Tetraden. Wahrscheinlich aus 2 hervorgegangen.
  8. Ueberschüssige Kerne in den Zellen der Tetrade. Wahrscheinlich aus 6 hervorgegangen.

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* Juel, Beiträge zur Kenntniss der Tetradentheilung. 2. Die Tetradentheilung bei einer hybriden Pflanze. Jahrb. Wiss. Bot. **35**: 638. 1900.

I wish to call attention especially to number 6 of the above table, namely, to that form of irregularity in the distribution of the chromosomes by which a portion of them are thrown out of the nucleus, a portion only remaining. The result of this might be, as Juel suggests, that the nucleus of the tetrad would contain chromatin of pure descent, that is, chromatin derived from one and not from both parents.

Guyer * has studied the spermatogenesis of hybrid pigeons and of hybrid cannas and found in both cannas and pigeons similar mitoses; consequently it will be necessary to speak only of the mitoses in the hybrid pigeon. I shall quote direct (*l. c.* 312):

"In the spermatogenesis of hybrid pigeons several abnormalities are manifested. These may be classified conveniently under three heads: (1) abnormalities in the structure of the spermatozoa; (2) abnormalities in mitoses; (3) degeneration of the germinal cells. Abnormalities in the spermatozoan structure were present in sterile hybrids, the most noticeable feature being a varicosity or swelling about the middle of the head. In tracing the development of the spermatozoa, this curious modification was found to be due apparently to a lack of development of the head; the nucleus did not elongate completely as in normal spermatogenesis. Abnormalities in mitosis were marked in both fertile and sterile hybrids. Large numbers of multipolar spindles were present. These were usually of the tripolar type. Occasionally two distinct and separate spindles occurred in one cell. The spermatocytes of the first order were the cells that showed this phenomenon to the greatest extent. In the normal pigeon the chromosomes in the spermatogonia are sixteen in number and in the primary spermatocyte eight. The latter are laid down in rings and each is evidently double. On the spermatogonia of the hybrid there were sixteen chromosomes and in the primary spermatocyte often more than eight. In the latter there may be several of the large double type and a number of smaller rings, or sixteen small ring chromosomes may occur. If sixteen rings were present they were usually located on two separate spindles, eight to each spindle.

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* Guyer, Spermatogenesis in Hybrid Pigeons. Science, II. 11: 248, 312. 1900; Some Notes on Hybridism, Variation and Irregularities in the Division of the Germcell. Science. II. 15: 530. 1902.

Another peculiarity in the mitosis was the frequent inequality in the division of the chromosomes, in some instances only about one fourth of a chromosome going to one pole." At page 248 he concludes that "these peculiarities in chromosome formation may point perhaps to a tendency in the chromatin of each parent species to retain its individuality. If such is the case, then in those cells with two spindles each bearing eight chromosomes, it is evident that after division, some of the new cells will have chromatin from only one of the original parent species, and some from the other. Some of the spermatozoa, therefore, will bear chromatin from only one of these species. It is a well-known fact that the offspring of hybrids are extremely variable, a portion of these variations being usually in the form of reversions to one or the other of the parent species. The possibility presents itself then, that this reversion may be due to the persistence of the chromatin of only one species in one or both of the germ cells. Carrying the conception still further, the other variations in the offspring of hybrids may be due, perhaps, to the varying proportions of the chromatin of each species in the mature germ cells."

And, finally, Metcalf * has studied the spermatogenesis of hybrid *Gladiolus*. He finds a condition analogous to the two-spindle nuclei of hybrid pigeons in all of the pollen-mother-cells of the hybrid, and he also concludes from this that the two groups of chromosomes represent maternal and paternal derivatives respectively. It is not stated whether the hybrid is a fertile one.†

In addition to the cytological studies as above outlined, some work on the structure of hybrids has also been done. This may be summarized in the following paragraphs.

Macfarlane ‡ conducted an extensive series of investigations on the minute anatomy of several hybrids, his main result being that all of the hybrids which he studied were intermediate in structure, even in the details, and his conclusion that the parents share equally in transmitting their respective characters.

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* Metcalf, Certain Problems Relating to the Individuality of Chromosomes. Proc. Neb. Acad. Sci. 7 : 109. N 1901 (read before the Academy, N 1900).

† Metcalf in a private letter assures me that the hybrid *Gladiolus* is fertile.

‡ Macfarlane, The Microscopic Structure of Hybrids. Gard. Chron. III. 7 : 543. 1890; A Comparison of the minute Structure of Plant Hybrids with that of their Parents, and its bearing on biological problems. Trans. Roy. Soc. Edinb. 37^1 : 203. 1892; Observations on Pitchered Insectivorous Plants. Ann. Bot. 7 : 445. 1893; Observations on some Hybrids between *Drosera filiformis* and *D. intermedia*. Contr. Bot. Lab. Univ. Penn. 2 : 87. 1898.

Farmer * studied the structure of *Polypodium Schneideri*, which is a hybrid between *P. aureum* and *P. vulgare*. The hybrid was reproduced by Farmer. The study showed the hybrid was not strictly intermediate either in form or structure.

In the following section of this paper I shall consider the relation of the results of the cytological studies of hybrids as above outlined, as well as of my own to be given later, to the variation of the hybrid race, but I may refer in this place to one or two considerations in connection with the possible bearing of the structural studies on the same topic. It is to be noted that Macfarlane studied only intermediate forms, but on the other hand the fern hybrid of Farmer's investigations was intermediate neither in form nor in structure. These apparently contradictory results raise the very interesting question, are hybrids, whether intermediate in form or not, always so in structure? Or can it be that variation in form is also associated with differences in structure? A careful histological study of hybrids that are clearly not intermediate, as for instance those following Mendel's *Pisum*-type could not fail to give most interesting results. And it may be added that the results from such study might be of importance in determining the hybrid status of the form.

THE RELATION OF THE CYTOLOGICAL TO THE EXPERIMENTAL STUDIES OF HYBRIDS

The task of the cytologist in the study of plant hybrids is primarily that of observing the relation of the manner of formation of the sex-cells to the variation of the hybrid itself, and it should for that reason include the study of hybrids which have yielded definite results from experiment, such forms, for example, as the *Pisum*-type. Owing however to the recentness of the discovery of the Mendelian laws, studies of this character have not been carried on, as far as I know, and conclusions to cover special cases of variation, for instance the *Pisum*-type, must therefore be regarded as tentative merely. Beyond this, general considerations, such as the fertility or infertility of the hybrid and the form of nuclear division in it, may give grounds for interesting and legitimate conclusions. It is of course only these general considerations that I can take up in the present paper.

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* Farmer, On the Structure of a Hybrid Fern. Ann. Bot. 11: 533. 1897.

From the summary of Juel's work on the *Syringa* hybrid it was seen that all of the maturation divisions were more or less abnormal. What may perhaps be considered the nearest approach to the normal division observed in this hybrid was an apparently typical achromatic figure accompanied by many small chromosomes, which were therefore not like those of heterotypic nuclear mitoses, and which did not split in the metaphase. And it is of interest to note that *Syringa* is probably a sterile hybrid.

Turning now to the results of Guyer from the study of fertile hybrid pigeons, we note that he observed both normal and abnormal mitoses, and some mitoses which were not clearly the one or the other. The latter are of particular interest since it is primarily these that he considers a possible basis for the variation of hybrids.* Among the irregularities in the mitoses in fertile birds, which may contribute to variation, is the following. In the dividing nuclei of some secondary spermatocytes two spindles occur, each bearing half the somatic number of small chromosomes.† As previously given, Guyer concludes (1) that the two-spindle condition shows a tendency in the chromatin of each parent to retain its individuality, (2) that by a proper separation and distribution of the chromosomes pure sex-cells would result, and (3) that the union of these might cause reversion. This conclusion appears to have been drawn before the publication of the Mendelian law.‡

If the form of maturation mitosis just described occurs generally in hybrids, and further if the chromatin is separated and distributed as postulated by Guyer, we should evidently not have to go further in order to discover the kind of mitosis that would produce in hybrids of the *Pisum*-type "pure" germ-cells — the important part of the Mendelian theory.§ There are however one or two considerations in this connection which may be worth bringing forward. In the first place the possibility arises that the spores that are formed from two-spindle nuclei in the mother-cells, even if functional, may contain chromatin from both and not from one parent only. To put this idea somewhat more directly, it may be that the failure of the maternal chromatin to unite with the paternal chromatin, which will be spoken of again presently, results not in the purity of the reproductive cells, but quite the contrary, in their being of hybrid nature. This has certain theoretical interest and will be again referred to. In addition to this the results of my own study of the spermatogenesis of hybrid cotton, which will be given in the following section, lead me to believe that the usual form of maturation division in fertile hybrids is quite like that in the pure race (as indeed Guyer also found in fertile pigeon hybrids), and therefore that the variations in the hybrid cotton are not dependent on irregularities in the mitoses, and consequently if irregularities occur it must be shown that the resulting spores are functional. (The possible exception to this will be given below.)

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* Guyer. Science, II. 11 : 248. 1900.

† Compare Metcalf on hybrid *Gladiolus*, *l. c.*

‡ In his most recent paper (see footnote on p. 155) which was received after this was written, Guyer considers it possible that "pure" reproductive cells may be derived from normal mitoses.

§ Bateson and Saunders, *l. c.* 12 : "the essential part of the discovery is that *the germ-cells or gametes produced by cross-bred organisms may in respect of given characters be of the pure parental types.*"

Now since all of the hybrids known to be fertile which have thus far been studied have perfectly normal maturation mitoses, in addition to clearly irregular ones, and further since in known sterile forms abnormal divisions only occur, it seems to me that the variations of the hybrids are either wholly independent of those divisions, or that the mitoses are fundamentally unlike what is now believed. Correns * has apparently reached the former conclusion; he does not think that irregularities in the maturation mitoses have any connection with the splitting of the hybrid race.

It now remains to be seen what sort of maturation mitoses there may be (1) which will result in the separation and distribution of the chromatin so that the ultimate sex-cells may have chromatin of pure descent, and (2) which will also appear to be the same as is believed to occur in pure forms, namely, a double longitudinal division of the chromatin segments.

I shall now refer to the account given by Wilson † of the formation of tetrads by conjugation, but more especially to his ac-

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* Correns, Ergebnisse der neusten Bastardforschungen für die Vererbungslehre. Ber. Deuts. Bot. Gesells. 19: 86. 1901.

† Wilson, The Cell, ed. 2. 1900.

count of the early history of the germ-nuclei. In speaking of the latter, Wilson says (*l. c.* 273): "A large number of observers are now agreed that during the growth-period preceding the maturation division, in both sexes, the nucleus of the mother-cell (spermatogonium, oögonium), both in plants and in animals, passes through some changes preparatory to reduction at a very early period. Thus, in the egg the primary chromatin-rods are often present in the very young ovarian eggs, and from their first appearance are already split longitudinally. Häcker made the interesting discovery that in some of the copepods (*Canthocamptus*, *Cyclops*) these double rods could be traced back continuously to a double spireme-thread, following immediately upon the division of the last generation of oögonia, and that *at no period is a true reticulum formed in the germinal vesicle.* In the following year Rückert made a precisely similar discovery in the case of selachians. After division of the last generation of oögonia the daughter-chromosomes do not give rise to a reticulum, but split lengthwise, and persist in this condition throughout the entire growth-period of the egg. Rückert therefore concluded that the germinal vesicle of the selachians is to be regarded as a 'daughter-spireme of the oögonium (*Ur-ei*) grown to enormous dimensions, the chromosomes of which are doubled and arranged in pairs.' In this case their number seems to be at first the somatic number (thirty-six) which is afterward halved by the conjugation of the elements two and two (Rückert), as in *Lumbricus* (Calkins). It is, however, certain that in many cases (insects, copepods) the double rods first appear in the reduced number." In another place (*l. c.* 257), Wilson says: "A considerable number of observers have maintained that reduction may be effected by the union or conjugation of chromosomes previously separate. This view agrees in principle with that of Rückert, Häcker and Vom Rath; for bivalent chromosomes assumed by these authors may be conceived as two conjugated chromosomes." It should be added further that Montgomery* and evidently Guyer as well † consider the conjugating chromosomes to be of unlike parentage. Therefore the heterotype rings of the normal mitoses in pure races of animals are not only of double origin, but they are so organized that the halves of any chromatin loop are of diverse origin, that is, one half is derived from the one and the other half from the other parent. So that in pure races of animals *if the chromatin is of pure descent*, and, further, *if the maternal and paternal chromatin is segregated as a result of the maturation mitoses*, the ultimate sex-cells are also of pure descent, two of any group containing chromatin lineally derived from one parent and two chromatin from the other. I therefore have suggested[*] that the same organization of the chromatin occurs in fertile hybrids, and that it forms the morphological basis for variation in accord with the Mendelian conception.[†]

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* Montgomery, A Study of the Chromosomes of the Germ Cells of the Metazoa. Trans. Am. Phil. Soc. **20**: 1901.

† Guyer. Science. II. **15**: 530. 1902.

The organization of heterotype rings by the conjugation two and two of previously distinct chromosomes appears thus to be fairly well founded, but the purity of the chromosomes as regards descent is, I take it, not so well established, and here may perhaps be sought a cause for variations outside of the *Pisum*-type. But there is also considerable evidence to show that the chromosomes preserve their individuality during the ontogeny, or if the chromosomes do not retain their individualty, at any rate that the chromatin may retain its purity. Wilson (*l. c.* 204) says: "Observations have given the strongest reason to believe that, as far as the chromatin is concerned, a true fusion of the nuclei never takes place during fertilization, and that the paternal and maternal chromatin *may* remain separate and distinct in the later stages of development—possibly throughout life." On page 299 this author treats the matter somewhat more fully and cites the work of Rükert and Häcker on *Cyclops*, and Herla and Zoja on *Ascaris*. Recently Häcker * has confirmed and extended his earlier conclusions, and in a recent paper Moenkhaus states that he has found that the paternal and the maternal chromatin may remain separate and distinct during several cell generations in hybrid fishes.

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[*] Cannon, A Cytological Basis for the Mendelian Laws. Bull. Torrey Club, **29**: 657. D 1902.

[†] This conclusion was also independently formed by W. S. Sutton: On the Morphology of the Chromosome Group in *Brachystola magna*. Biol. Bull. **4**: 24. D 1902. Guyer has recently advanced a similar conclusion: Hybridism and the Germ-cell. Univ. Cincinnati Bull. No. **21**. N 1902.

The hypothesis above given to account for the variation of the hybrid race after the type of Mendel's pea hybrids applies of course to those whose pure parents are separated by one character only, that is, to monohybrids, and does not clearly to polyhybrids, or to those whose pure parents are distinguished by more than one character. If, however, we find that the two-spindle condition obtains in the spore-mother-cells of fertile hybrids to a considerable degree it seems to me that in the combined results of such abnormal with the normal mitoses we may find a structural basis for the essentials of the variations in the more complex types of hybrids.

It has already been stated that the conjugation of the chromosomes occurs in pure races at some stage before the maturation divisions, and that by the separation of the chromosomes, provided they are lineally descended from parental chromosomes, the spores may be of pure descent. Now when in certain hybrids the conjugation fails to take place a mother-cell with a two-spindle nucleus may be formed as Guyer has stated, † and as he has shown in the fertile hybrids studied by him. Metcalf also found in hybrid *Gladiolus*, as I have mentioned in summarizing his work, chromosomes in two masses as on double spindles in the pollen-mother-cells and, finally, I have observed a few mother-cells in the hybrid cotton which may apparently had double spindles. In the cotton, however, this condition was the exception, as will be spoken of below.

Phenomena which are probably associated with the independence of the germ-nuclei have long been observed in hybrids. These comprise the greater influence of the one than the other parent, or, at the other extreme, the equal influence of both parents in the hybrid. Between these extremes are many intermediates some of which have already been mentioned (page 142). And it seems possible that in some hybrids the germ-nuclei may equally and independently mold the character of the cells, and not combine to effect this as in strictly intermediate hybrids. Farmer,‡ for example, gives an account of a hybrid *Oxalis* in some epidermal cells of which *trichomes typical of both parents* may be found in a single cell. Other cases illustrating this point might also be cited. It will thus be seen that a close study of the structure of a hybrid may be of considerable use in determining the relative independence of the germ-nuclei.

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* Häcker, Ueber die Autonomie der väterlichen und mütterlichen Kernsubstanz vom Ei bis zu den Fortpflanzungszellen. Anat. Anzeiger, **20** : 440–452. 1902.

† Guyer. Science. II. **15** : 530. 1902.

‡ Farmer. Ann. Bot. **11** : 542. 1897.

I wish now to turn from the considerations of nuclear divisions and hybrid variations and apply *theoretically* the principle of the purity of the sex-cells to a moss, a fern, and a seed-plant. In doing so I assume, as a matter of course, that the hypothetical hybrids are monohybrids of the *Pisum*-type. The theoretical application is made rather to call attention to what seems to me a very broad and inviting field for research, than to attempt at this time any development of the field myself. Many additional points of view will undoubtedly suggest themselves at once to any botanist.

We shall consider what happens when one sort of a moss is crossed with another sort, when the spores of the hybrid moss develop, and, finally, when the hybrid is inbred.

In the first place when a moss is fertilized by the sperms of a moss of another species, the moss "plant" is not hybridized, since the effect of the foreign fertilization is to be observed only in the *sporogonium*. This applies to the hybrid of the first generation; what happens in the later generations has apparently not been studied or at least recorded. Focke (*l. c.* 427) says that no hybrid sexual moss plants (gametophytes) have been recognized, and he inquires if some of the numerous sterile mosses may not be hybrid. According to the hypothesis of the purity of the spores we should not expect to find hybrid gametophytes in any generation. And in this connection it is certainly interesting to note that there is said to be no hybrid among the liverworts. This again would be the case if the spores from which the liverwort "plant" arises are not hybrid but pure, and we may perhaps make the rule that *it is the sporophyte, and not the gametophyte, which is of hybrid nature.*

Assuming the purity of the spores, when the hybrid is inbred variation of the sporogonia would occur according to the law of Mendel, but not necessarily according to the *Pisum*-type. The variation of the hybrid will depend on the monoecious or dioecious nature of the moss. This will be clear when we examine the formulae for variation of monoecious and of dioecious ferns.

Turning now to the fern hybrids, we shall first consider a monoecious homosporous hybrid, and, finally, a dioecious homosporous hybrid.

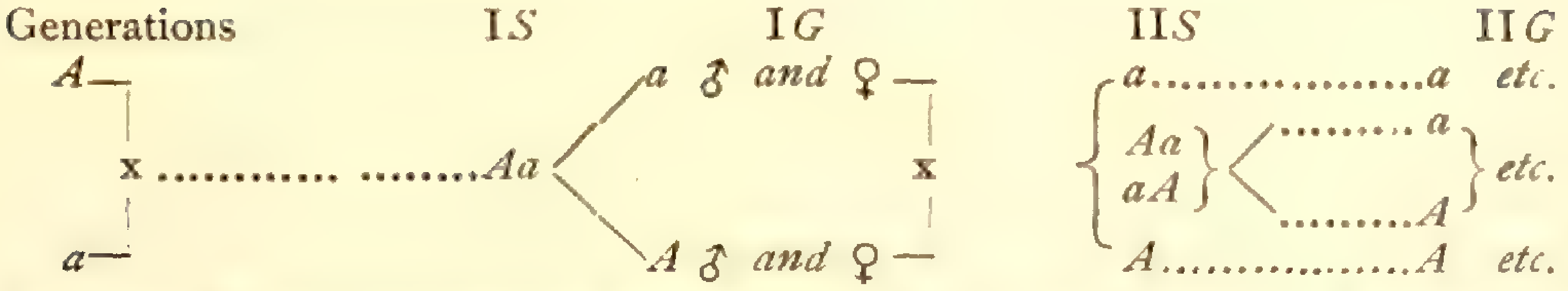

FIG. 2. Hybrid homosporous *monoecious* fern. Explanation. *S*, sporophyte; *G*, gametophyte; *A* and *a*, the chromosomes of the two races, when combined (*A a*) the form is hybrid.

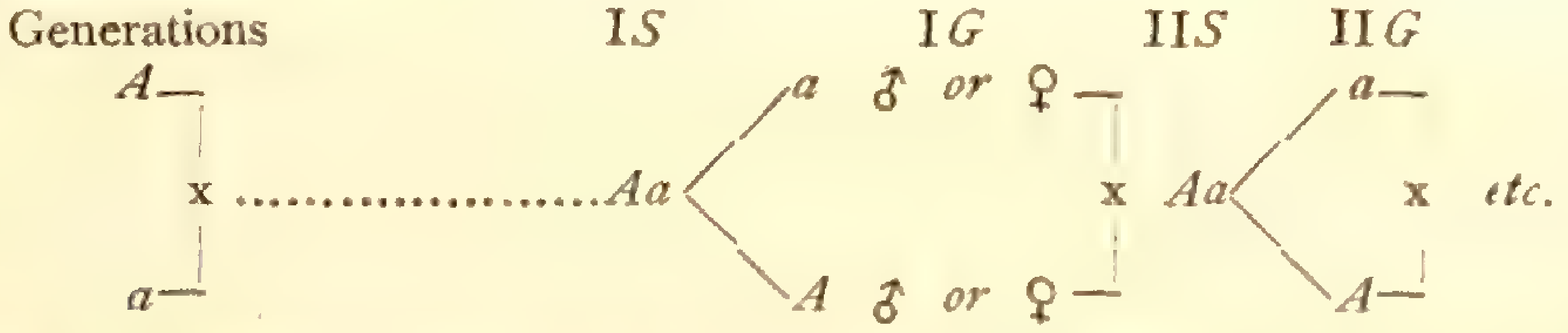

FIG. 3. Hybrid homosporous *dioecious* fern. *Lettered as the preceding figure.*

In contrasting the two formulae for fern hybrids as given several points may be worth speaking of. In the first place the fern hybrids with monoecious prothallia revert after the *Pisum*-type of Mendel; and secondly the hybrids with dioecious sexual generations are always some form of intermediate, and never revert. Dioecious forms also, such as *Equisetum* hybrids, suggest problems of interest not necessarily closely connected with their hybridity. Among these the following may be mentioned: Dioecious ferns viewed from the standpoint of the purity of the spores, and hence of the sex cells, give suggestions as to the morphological basis of the origin of heterospory. Coulter * says: "The evolution of heterospory seems simple enough. The physiological differentiation of the spores was complete when prothallia became persistently dioecious. * * * A prothallium producing both sex organs equally well may be regarded as in a state of equilibrium, an equilibrium which is disturbed by any conditions which favor the production of one sex organ rather than the other, in this case probably nutritive conditions. This disturbance of the equilibrium of a bisexual prothallium would certainly find an expression first in a dioecious tendency, and finally in a dioecious habit. With the habit once fixed the morphological differentiation of spores becomes inevitable, since the nutritive requirements of the two prothallia are so different. The evolution of heterospory seems to be one of the simplest of selective processes, with inequalities of nutrition to furnish the variations."

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* Coulter. Bot. Gaz. **26**: 163. 1898.

I would suggest that the transmission of a *dioecious tendency* is morphologically possible because the spores that give rise to the prothallia are pure, and, therefore, we conclude, tend to reproduce the same sort of prothallia as the ones from which they sprang in the preceding generation, and that the *dioecious habit* is likewise only possible by a continuance of the same process through many generations. By referring to Fig. 3, the formula for a dioecious fern hybrid, it is seen first that the gametophytes are of pure descent, and further that the fern is dioecious, so I suggest that the spores A will produce prothallia like those from which the chromatin of their nuclei was derived and, also, that the spores a will give rise to prothallia like a of the pure form, that is, in *dioecious hybrid ferns, or the pure races, the prothallia that arise from A or a will be male or female accordingly as the sexual ancestor of that spore was male or female.* In other words, may not the purity of the spores be the groundwork upon which the selective processes play that bring about the dioecious from the monoecious condition, that deepen the dioecious tendency into a dioecious habit, and, finally, give rise to the morphological condition known as heterospory?

We may now return from this disgression to examine very briefly what happens when seed-plants of different sorts are crossed.

We should note first that the formula commonly given for the hybrid fertilization and variation in seed-plants is somewhat misleading since it does not take account of the sexual generation, which we believe in the monohybrid seed-plants of the *Pisum*-type, if indeed not in all others, is always pure. Secondly, it is the heterosporous condition of the higher plants, in the place of the homosporous monoecious one of the fern mentioned above, that makes possible the formula ($A + A$; $A + a$; $a + A$; $a + a$) of the hybrid of the *Pisum*-type. Now we may ask, what morphological conditions are prerequisite for the development of this formula? It is clear in order that this end may be reached that the anthers must organize spores with A and spores with a characters and likewise that the ovary must maturate functional spores with A and with a characters. Now as a matter of fact in the higher plants three of the potential macrospores usually degenerate and one only germinates, so that in any ovule one character, and one sort of chromatin, are eliminated from the problem. Therefore the reversion to one or to another of the pure parents might not under certain conditions take place. It thus is necessary in order to effect the splitting after the *Pisum*-type that on the average, taking many plants together, an equal number of each sort of germ-cells of the same descent shall degenerate, and that a like number shall become functional. The variability of the higher plants as regards the development of the macrospores may thus in a broad way account for certain conceivable modifications or apparent exceptions to the Mendelian law, so that the morphology of the hybrids must needs be studied if the structural basis for hybrid variation is to be understood.

We have then sketched what supposedly takes place when mosses, ferns and also when seed-plants of the *Pisum*-type are hybridized, and the general and particular conclusions may be summed up thus:

1. In monohybrids of the *Pisum*-type the spores and the immediate spore derivatives are pure as regards the chromatin content of their nuclei. The application of this principle to the *liverworts* accounts for the apparent lack of hybrids among them, either in the first or in the later generations; applied to the *mosses* it accounts for the failure to recognize hybrids in the second and later generations. In both liverworts and mosses the "plant" (gametophyte) is of pure descent in any generation, and the sporogonia only are hybrid. This last consideration leads to the generalization that in *plants of whatever class where hybridity occurs it is perhaps always the sporophyte only which is hybrid.**

2. In the ferns the chromatin may be transmitted from one sexual generation to another in such a manner as to retain its individuality and thus it may tend to reproduce the sort of gametophyte from which it descended, and in dioecious forms the sex also, so that *the purity of the spores forms the background that may make the genesis and the evolution of heterospory a morphological possibility.*

It is likely that the study of such hybrids as have distinct sexual and asexual generations would be of advantage since in them a morphological analysis of the nature of a hybrid might be made, and thus a clearer understanding of the nature of hybridity in general but particularly the nature of hybridity in such forms as do not have distinct sexual and asexual generations might be obtained, that is, the hybrids among the seed-plants.

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* The possible exceptions to this have already been referred to (page 155).

THE SPERMATOGENESIS OF HYBRID COTTON

The cotton hybrid used in this study * was grown from seed obtained by crossing the Sea Island (Constellation brand) with upland (Klondike brand) cotton, *Gossypium Barbadense* × *G. herbaceum.* The crossing was done expressly for this study by Dr. H. J. Webber, of the Department of Agriculture, in the experimental plots near Columbia, South Carolina. Concerning this cross Dr. Webber writes as follows:

"The flowers were emasculated August 22, 1900, and crossed August 23, the resulting boll producing ten seeds; all of the seed of this we sent to you. But 34*a*, which is of the same parentage and crossed at the same time in our plots at Columbia, all proved to be without question hybrids, being very tall and rank and rather unfruitful, showing in practically every character their hybrid nature." He further says that "34*b* is without much question a true hybrid." The seeds from the cross known as 34*b* were sown in pots in the propagating house at the New York Botanical Garden, about July 20, 1901, and the plants that were derived from these seeds were used by me in this study.

The cotton plants, 34*b*, formed buds in October and the first lot for study was put up on the 29th, and after that at intervals of a week or so as often as the buds appeared to be of the proper size. The hybrids appeared to correspond to the description that Dr. Webber gave for the hybrid of the same parentage, 34*a*, and the 34*b* forms were evidently true hybrids. It was evident also that these hybrids were fertile, but to what degree I was unable to determine, since most of the flowers were removed for study.

Before describing the maturation divisions I may anticipate my results by saying that abnormal sex-cells were present in practically all anthers, and, except in the last flowers formed, normal cells as well. The ratio between the two was an inconstant one; in this regard the cotton is different from the *Gladiolus* hybrid, and agrees with the pigeon and *Canna* hybrids, as will be seen by referring to the summary given above. I may also say that my principal object in making the study was to learn whether the mitoses were different from those in pure races of analogous plants, rather than to make an exhaustive study of the divisions as such, and for this reason my material was not suitable for the study of the earlier stages, however important that may be.

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* I wish here to acknowledge my obligations to Dr. Webber, who kindly made the crosses for me and always encouraged the work; to Professor Underwood, of Columbia University, for his counsel and assistance, and to the officers of the New York Botanical Garden, especially to Dr. MacDougal, who placed the excellent facilities of the Garden at my disposal.

I shall turn now to the morphological part of the paper. The divisions in the normal cells will be spoken of first, and then I shall give some account of the various irregularities which may be seen in the abnormal mitoses of the hybrid.

The archesporial cells arise by the division of subepidermal cells and become pollen mother-cells directly, no formation of sporogonous tissue occurring. After the two divisions of its nucleus, the mother-cell undergoes two simultaneous divisions by which the tetrads are formed, and these probably become pollen grains in the usual manner, although the later history of the cells was not learned. The mitoses leading up to the formation of the tetrads are as usual heterotypic and homotypic, and therefore are the same as are found in like mitoses of analogous organisms.

The cytoplasm of the archesporial cells is of a recticular or alveolar structure, and this structure is uniform throughout the cytoplasm of the cell. That is, the portion of the cytoplasm which is immediately around the nucleus is not differentiated from the portion which is in the more peripheral part, but has a similar appearance and structure. This primitive, or undifferentiated condition of the cytoplasm is retained in all cells in which direct nuclear division occurs, but on the other hand it may not be observed in the normal cells. Thus the structure of the cytoplasm forms an interesting and reliable check to the observations of the older stages of development of the cells.

When those of the archesporial cells which are to develop into normal pollen grains become spore mother-cells, the cytoplasm withdraws from the cell walls. This retreat of the cytoplasm may also be observed in certain of the abnormal cells, for instance, in those which do not undergo degeneration in the earlier stages, as will be spoken of again in this paper. The withdrawal of the cytoplasm is to be regarded as the normal and regular occurrence in the archesporial cells of cotton, and is not therefore analogous to the condition observed by Juel in *Syringa*[*] where it was an indication of degeneration.

About the time of the formation of the spore mother-cells, and as a regular structural change accompanying it, the cytoplasm of the normal cells shows a marked change in its structure. A zone of dense protoplasm which takes the cytoplasmic stain with avidity, is formed around the nucleus in contact with the nuclear wall. This perinuclear zone is found also in the developing pollen grains of various plants of pure descent.[†] It is seen not only in the cytoplasm of the spore mother-cell, but in the later stages as well, even in the young tetrads as in *Lavatera*.[‡] The structure of the zone appears to be granular, although in some preparations and under comparatively powerful magnification—Zeiss ocular 18, apochromatic oil-immersion 2-mm. objective—it seemed reticular, thus resembling *Larix*.[§] Outside of the perinuclear zone is the main portion of the cytoplasm which is alveolar in structure and in addition to these two sorts of protoplasm a layer of fibrillae midway between the periphery of the cell and the perinuclear zone is also occasionally found in the spore mother-cells. When first observed the fibrillar layer is of a rather loose structure, but in the older cells the fibrillae are closely bound together and form a compact zone.

A similar zone is figured by Mottier for *Lilium*.[||] This filar plasm, like the achromatic figure, takes the gentian-violet with Flemming's triple stain. As a rule the spore-mother cells do not contain this structure, but it is found with great regularity in the cytoplasm of the older cells. The genesis of the fibrillar layer is difficult to account for in the spore mother-cells; in the later stages of development, however, it is formed by the mantle fibers which stray into the cytoplasm from the two poles of the spindle.

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[*] Juel, *l. c.* 640.

[†] Lloyd. Mem. Torrey Club, **8**: 71. 1902.

[‡] Byxbee. The Development of the Karyokinetic Spindle in the Pollen-Mother-Cells of *Lavatera*. Proc. Calif. Acad. Bot. III, **2**: 63. 1900.

[§] Belajeff, Zur Kenntniss der Karyokinese bei den Pflanzen. Flora, **79**: 430. 1894.

Mottier, Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen etc. Jahrb. Wiss. Bot. **30**: *pl. 3. f. 5.* 1897.

My material was not suitable for the study of the early history of the chromatin of these cells and therefore the account of the maturation divisions begins with the spore mother-cell and includes the two maturation mitoses by which the tetrads are organized.

The first indication of the approaching first division of the nucleus of the spore mother-cell which was observed was the aggregation of the chromatin to one side of the nucleus and the formation there of the spireme. Thus synapsis occurs before the mother-cell withdraws from the cell-wall (*f. 1*). The spireme ribbon loosens and at length its convolutions extend throughout the nucleus. At first the spireme has a beaded appearance and an uneven outline, but in the older nuclei the contour is much more uniform and the structure much more dense. At the same time the spireme increases in its power of absorbing stains. Particularly in the later stages the splitting of the spireme was observed with great clearness.

When the spireme forms segments, the chromatin for a second time collects to one side of the nucleus, and in that situation the shortening and thickening of the segments takes place. The segments are long and in delicate loops when first clearly made out; the loops are much twisted and bent in a variety of ways. The ends of the loops are not infrequently connected by delicate protoplasmic strands, indicating perhaps that the fusion of the adjacent chromosomes had not been a complete one (*f. 4*), and it also may happen that the union of the chromosomes did not take place exactly at their ends but at a greater or less distance from them. Usually, however, the loops are entire and symmetrical and give no hint as to their possible origin or formation. Very frequently in the long chromatin loops a longitudinal splitting may be seen, which must evidently be regarded as a precocious process looking to a subsequent separation of the divided portions.

The chromatin loops shorten and thicken to form rings and they in turn by further condensation lose the ring character, but in the metaphase of the first division this character reappears.

In any nucleus the loops and the rings are of a uniform size, that is, the two sizes of rings found in the hybrid pigeon * and in some pure forms in plants † were not observed in the cotton.

At the time when the chromatin segments are becoming condensed and have gathered at one side of the nucleus, characteristic changes are also taking place in the structure of the perinuclear zone of cytoplasm. The inner portion of this becomes less dense and is finally replaced by a coarse reticulum of delicate protoplasmic strands. This network unites with the nuclear wall on one side, and joins the more peripheral and unchanged portion of the perinuclear zone on the other. The reticulum is therefore from its genesis wholly of cytoplasmic origin.

While the changes in the perinuclear zone are occurring as above described, certain developmental modifications may also be observed in the nucleus. Until this time the linin of the nucleus has not been noticeable, but now it assumes a more or less granular appearance and stains feebly, and the nuclear wall shows indication of approaching disintegration. Delicate threads of protoplasm run out from it which join, on the outside, the circumnuclear reticulum, and on the inner side, the linin meshwork. Shortly the nuclear wall becomes entirely broken down and a continuous protoplasmic reticulum occupies the entire cell.

The relation of the karyoplasmic reticulum to the perinuclear zone in the formation of the achromatic figure will be spoken of directly, and it may be premised that it is the same as is found in *Cobaea scandens* ‡ and in *Lavatera*,§ as well as in other plants, that is the achromatic figure has elements drawn both from the cytoplasm and from the nucleus.

The topographic relations of the cell constituents at this time will be understood by referring to *f. 7*. When such a section is treated with the Flemming triple stain, the perinuclear zone will be colored deep orange, the reticulum within the perinuclear zone will be colored lightly with the gentian-violet, and, finally, the chromatin will of course take the saffranine.

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* Guyer. Science, II. **11**: 248. 1900.

† Strasburger, Histologische Beiträge, **6**: 42. 1900.

‡ Lawson, Some Observations on the Development of the Karyokinetic Spindle in Pollen-Mother-Cells of *Cobaea scandens*. Proc. Calif. Acad. Bot. III. **1**: 169. 1898.

§ Byxbee, *l. c.*

Prior to the breaking down of the nuclear wall the nucleolus (plasmosome) presents indications of its disintegration. Its capacity for absorbing the stains is lessened, it becomes vacuolated, and at length disappears. The degeneration of the nucleolus takes place *pari passu* with the formation of that portion of the nuclear reticulum which is of karyoplasmic origin, and it may, in fact, contribute to its building up, just as occurs according to Strasburger in *Fucus.**

The net-work which arises from the linin of the nucleus, from the cytoplasm immediately surrounding it, from the disintegrated wall, and finally, perhaps, from the nucleolus also, becomes modified so that a confused mass of fibers are formed which make the felted condition characteristic of the earlier stages in the organization of the multipolar achromatic figure in the higher plants. The fibrillae which come from the reticulum become gathered into groups with the effect that from the felted condition a multipolar one ensues, and from this at length the bipolar figure is formed. Several intermediate stages were observed in the transformation just spoken of, such as the one figured (*f.* 8). The cytoplasmic cones, which are so prominent a feature in the early stages of such an achromatic figure as in *Equisetum* † are wholly wanting in the cotton hybrid. The presence of the perinuclear zone of cytoplasm, as has been pointed out in *Lavatera*,‡ appears to inhibit the formation of the *Equisetum* type of multipolar figure.

When the achromatic figure is completely differentiated, the poles extend nearly or quite to the periphery of the cell, and the relation between the achromatic figure and the ectoplasm is the same as described by Lloyd § as occurring in *Asperula*. In the cotton the relation is a variable one, and appears to depend on the size of the cell, as for instance, in the spindles of the second division the poles do not reach to the periphery but terminate in the outer portion of the cytoplasm. The achromatic figure of the cotton hybrid, as in pure races, is made up of three sorts of fibers, namely, of the continous fibers, or central cylinder, the contractile fibers, and the mantle fibers. The continuous fibers and the contractile fibers arise from the intra-zonal network in a manner above described, but the mantle fibers appear last, they are composed wholly of cytoplasmic material, and apparently are not at all concerned with the splitting or separation of the chromosomes. The mantle fibers give rise to the fibrillar layer which was spoken of above and which is a conspicuous element of the cell after the first nuclear division.

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* Strasburger, Kerntheilung und Befruchtung bei *Fucus*. Jahrb. Wiss. Bot. 30: 351. 1897.

† Osterhout, Ueber Entstehung der karyokinetischen Spindel bei *Equisetum*. Jahrb. Wiss. Bot. 30: 159. 1897.

‡ Byxbee, *l. c.*

§ Lloyd, *l. c.* 70.

The chromosomes become arranged so as to form a plate midway between the poles of the bipolar spindle and at right angles to the spindle. In the metaphase of the first division the chromosomes are usually ring-shaped but vary more or less as in the metaphase of this division in pure races of plants. However, when first arranged in the plate the ring form may not appear, but it does subsequently, during the process of the splitting of the chromosomes. I was not able to determine with certainty whether the first split separated chromosomes which corresponded to the two halves of the heterotype ring, or whether the split followed the second cleavage. If the former occurs, then according to the hypothesis advanced in the preceding part of this paper, the daughter nuclei are pure as regards the chromatin content. If, however, the latter is the case, the nuclei of the daughter cells would be of mixed descent. The tetrads in either case * would contain chromatin which had descended in a linear manner from either and not both of the parents.

In the anaphases of this division the chromosomes are U-shaped, V-shaped or X-shaped as in pure forms. The second longitudinal splitting which was observed in the prophases, could not be clearly made out in the anaphases because the chromosomes were so small and dense. By repeated counting of the chromosomes, I determined that there was an equal distribution of them in the first mitosis: the reduced number was 28.

In late anaphase the chromosomes take a position at some distance from the poles, so that when the reconstruction begins the ends of the spindle extend beyond (*f. 12*).

Certain characteristics of the achromatic figure may be mentioned in this place. The mantle fibers extend from the poles, at a sharp angle to the spindle, well into the cytoplasm, and make up the fibrillar layer which is so conspicuous in the cells. Those of the fibers that are in the immediate neighborhood of the daughter nuclei soon lose the filar appearance, become structureless and the chromosomes in early telophase lie freely in an apparently homogeneous substance.

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* It is conceivable, however, that a *different orientation* of the heterotype rings might give other results.

The reconstructed nuclei possess a distinct nuclear wall, the chromatin forms a coarse reticulum (*f. 12*) and the nucleolus is reconstructed. The steps in the reformation of the daughter nuclei were not closely observed but appeared roughly to correspond to the reverse of the breaking down of the mother nucleus.

When the daughter nuclei are fully reconstituted the fibers of the achromatic figure may still be seen in the inter-nuclear cytoplasm; they persist during the division of the nuclei and even may be observed in the cytoplasm of the young tetrad. The presence of these spindle-fibers in normal mitoses, and the total absence of them in abnormal ones, form a reliable basis for judging whether the mitosis was normal or abnormal, but this of course would probably not be true if the divisions were so nearly normal as some described by Juel, Guyer and Metcalf. Such, however, are not to be found in the cotton hybrid.

The daughter nuclei are so small that it is difficult to study at all closely the sequence of changes which lead up to and accompany their division, and, therefore, I contented myself with observing certain definitive phases only.

Continuous, contractile and mantle fibers are of course present in the achromatic figure, but the latter do not eventually form a fibrillar layer in the cytoplasm as the mantle fibers of the preceding division do. The continuous fibers persist and may be seen along with those from the first division in the young tetrad.

In the prophases of this division the chromatin masses arrange themselves in a nuclear plate as in the former division, but there is a distinct difference between the chromatin of the first and of the second mitosis. In the prophases of the second mitosis the chromosomes are of a uniform size and appearance and are rod-shaped. I was not able to make out the presence of the second and precocious split which in some forms may be observed at this time. In the metaphase each chromosome divides into two equal portions, and these go to the opposite poles of the spindle and there build the tetrad-nucleus.

Although in many regards the description of the mitoses just given must be considered as a meager one, I think that enough has been said to show that they are the exact homologues of these nuclear divisions in pure races of plants. That is, in the cotton hybrid the first maturation is a heterotypic one and the second is homotypic.

My material was not of sufficient amount or kind to permit me to study the subsequent nuclear division of the tetrad, or the germination of the spore.

The division of the cell does not take place until the daughter nuclei are formed and completely reconstructed. When the division occurs the planes of division are at a sharp angle with one another and pass between the daughter nuclei, and the result is an equal apportionment of the cytoplasm among the four nuclei of the group. Indentations appear in the periphery of the cytoplasm and midway between the nuclei, which deepen into constrictions, and finally accomplish the separation of the nuclei and the formation of the tetrads.

A cell-wall is not organized until the tetrads are built and the formation of the wall takes place as follows: colorless accretions appear on the periphery of the tetrad; later a delicate membrane may be distinguished connecting them. Both the thickened portions and the membrane are evidently produced by secretion and respond to the test for cellulose. Somewhat later the spore-wall becomes relatively thick by the addition of the cuticularized exine; the places where the cellulose accretions first appear mark the location of the germinal pores.

Abnormal Nuclear Divisions. — The foregoing account of the tetrad formation in hybrid cotton is based on the study of anthers which were among the first to be put up, namely October 29, and were taken from the form known as "34*b*." A study of material collected in November and December showed that most of the male cells were perfectly normal. The flowers gathered in January were unfortunately older, and did not therefore show the division stages, but the appearance of the cytoplasm as well as of the nuclei was such as to indicate that normal mitoses had taken place. In all of the material, however, which was gathered later in the season, and which had nuclei in the process of division at the time of putting up amitosis occurred. I have not been able satisfactorily to determine whether these abnormal divisions were due to the cultural conditions, to the fact that the plant was a hybrid, or to both these factors with the added one that the flowers were the last to form on the plants.

A sharp distinction was made in the cotton between the nuclei of the abnormal cells which accomplished division, and those that were abnormal but degenerate and never underwent division either by the direct or by a modification of the indirect method. Degeneration of the sex cells, either of the archesporium or in later stages, could be found to some extent in practically all of the material examined, but this was always so well marked structurally that no confusion arose by which the degeneration of the cells was questioned.

When the degeneration took place in the archesporial cells it was very noticeable both in the nucleus and the cytoplasm. The cytoplasm assumed various conditions and structures. It was a coarse reticulum of rather delicate meshes which had a uniform appearance as if the microsomes were wanting, or a large vacuole occupied the center of the cell, pushing the nucleus to one side and causing the cytoplasm to gather in various parts of the cell. The cytoplasm of the degenerate cells takes stains with great avidity. This is especially to be noticed in the anthers that have both normal and degenerate nuclei. When in such anthers the cytoplasm of the normal cells is properly stained that of the degenerate cells will always be badly overstained. This is very different from the staining capacity of cells whose nuclei divide by the direct method, since these cells stain in a perfectly normal manner.

The nuclei of degenerate archesporial cells are often smaller than those of the normal cells in the same anther, the nuclear membrane is frequently very pronounced, and the chromosomes are of the size and number of the somatic ones. I found a few cells which were preparing for the first division and which had the two-spindle condition observed by others in hybrids; but I did not notice any such nuclei in later stages, since these cells degenerate before the divisions are completed. It is possible that the same plants grown under other conditions might have carried the divisions farther. Besides the irregularities in division as just given, others, especially in the achromatic figure, were also noted; in some cells the multipolar spindle was seen accompanied by many small nuclei.

Another form of irregularity occurred which is not so clearly degenerate but which must also be considered a factor that leads to infertility, namely the direct nuclear divisions in cells gathered the later portion of the winter. The mother-cells of the nuclei which were to undergo direct division were apparently like their counterparts in which normal mitosis would occur except as regards the structure of the cytoplasm, which retains its primitive condition; that is, a perinuclear zone is not differentiated, and a fibrillar layer is not present. The process of amitosis consists of a division of the nucleolus, followed by an equal or an unequal direct division of the remainder of the nucleus such that a nucleolus goes to each daughter nucleus.

The first amitotic nuclear division is usually equal, and the result of the division resembles that brought about by the indirect method, and also the second division may be equal and thus a tetrad group in appearance, much like that normally organized, may be formed. Usually, however, the divisions are not equal and small nuclei are associated in the same cell-complex with larger ones. The extreme is to be seen when the nucleus of the mother-cell fragments and the cytoplasm contains numerous small nuclei. Some of the forms of direct division are shown by figures *17*, *18* and *19*.

Cell-division may or may not follow the direct nuclear divisions. If it does, tetrads which are like the normal ones except as to the presence of small nodes will be formed; if, however, cell division does not take place, monstrous pollen grains result. Since the tetrads formed as a result of direct division may be like those organized in the regular manner a mere macroscopic examination of the mature pollen will give no indication of the genesis of such, and hence, it may be supposed, of its ability to germinate.

By way of general summary, I may say that in the anthers of the hybrid cotton one finds both normal and abnormal conditions.

The first maturation division in the normal cells is heterotypic, the second homotypic; and also amitosis occurs. Many additional abnormalities in the nuclei were observed; such nuclei, however, do not undergo division, but degenerate in the archesporial cell or some later stage, in every case before the first division. Among such irregularities a few mother-cell nuclei were observed with two spindles and the somatic number of chromosomes.

COLUMBIA UNIVERSITY, 1902.

Explanation of Plates

PLATE 7

FIG. 1. Microspore mother-cell.

FIG. 2. Same.

FIG. 3. Split spireme in prophase of first division.

FIG. 4. *a*, *b*, *c*, *d*, *e*; typical chromatin loops from the prophases of the first division, showing the double splitting.

FIG. 5. Same at a later stage.

FIG. 6. Condensation of rings into chromosomes preparatory for the first division; breaking down of the nuclear wall.

FIG. 7. Same, later stage.

FIG. 8. A multipolar spindle which is becoming a bipolar one.

FIG. 9. Metaphase of the first division.

FIG. 10. Anaphase of the same division, somewhat to one side of the median line; in the section next to this one the poles of the spindle were observed to extend quite to the periphery of the cell.

PLATE 8

FIG. 11. Chromosomes in the metaphase of the first division.

FIG. 12, *a*. Resting daughter-nucleus. *b*. Sketch of same nucleus, from the next section, showing its relation to the spindle, and that of the latter to the periphery of the cell.

FIG. 13. Daughter-nuclei; the reticular character of the cytoplasm not well shown; the presence of inter-nuclear fibrillae, the remains of the continuous fibers, is indicated.

FIG. 14. Early anaphase of second division; the more heavily shaded portion of the cytoplasm indicates the position of the perinuclear zone; the fibrillar layer in the cytoplasm is shown.

FIG. 15. Metaphase of the second division.

FIGS. 16–19 are of abnormal (amitotic) nuclear division of spore mother-cells.

FIG. 16. Daughter-nuclei.

FIG. 17. Nuclei of different sizes.

FIG. 18, *a* and *b*. Tetrads with smaller nuclei scattered in the cytoplasm.

FIG. 19, *a* and *b*. Equal and unequal direct division of the nucleus of the mother-cell.

NOTE. — The primitive character of the cytoplasm is shown in Figs. 16, 17, 18*a* and 18*b*.

Timothy Field Allen

By N. L. Britton

(With Portrait)

Dr. Timothy Field Allen, for many years a vice-president of the Club, died at his residence in New York City, December 5, 1902.

He was born in Westminster, Vt., April 24, 1837. His collegiate training was at Amherst, from which institution he was graduated in 1858. His degree of Doctor of Medicine came from the medical department of the University of New York in 1861, and during the years 1862–1864 he served as an Assistant Surgeon of the United States Army. Returning to New York toward the close of the Civil War, he formed a partnership with the late Dr. Carroll Dunham, and has since been an active practitioner of homeopathy, serving for a series of years as dean of the New York Homeopathic Medical College and Hospital; he was also largely instrumental in the establishment of the "Flower Hospital" and the "Laura Franklin Free Hospital for Children."

At the time of his return to New York from service in the army, or previously, he became interested in botany, and soon became intimately associated with Dr. George Thurber, Mr. William H. Leggett, Mr. Coe F. Austin, Professor D. C. Eaton, Mr. J. H. Redfield, Mr. James Hogg, Mr. M. Ruger, Mr. James S. Merriam, Mr. Isaac Buchanan, and others, who under the inspiration of Dr. John Torrey, were enthusiastically prosecuting the study of the local flora, and met regularly as early as 1865 as the New York Botanical Club; it is recorded that the suggestion for the formation of this organization came from Dr. Allen. As the organization became more formal, and of increasing influence, it was determined to apply to the legislature of the State for an Act of Incorporation, which was first granted April 21, 1871, and amended April 29, 1872, the name "Torrey Botanical Club" meanwhile having been appropriately substituted for the original designation. Dr. Allen served as Curator, and the local herbarium was kept at his residence, the meetings being held in Dr. Torrey's rooms at Columbia College. After the death of Dr.

Torrey in 1873, Dr. Thurber succeeded to the Presidency of the Club, and Dr. Allen was elected Vice-President, an office which he held continuously from that time until his death.

During the early years of the Torrey Club, Dr. Allen was a diligent observer and collector of the plants growing in the vicinity of the city, and was actively interested in the field excursions, which were early established and have been continued consecutively ever since. Many of his specimens are preserved in the present local herbarium of the Club, which now forms the nucleus of the local herbarium of the New York Botanical Garden. He also collected extensively in the vicinity of Litchfield, Conn., which has been his summer home for many years. In June, 1870, he explored Lookout Mountain in Tennessee and Georgia, He became interested in the study of Algae during his association with Professor D. C. Eaton in New York, and soon specialized on the family Characeae. As early as 1871 he records that he had been interested in this group for some years, and his botanical studies of these plants continued until his health failed in 1901. His printed contributions to the knowledge of the Characeae are numerous, and are cited in the appended bibliography: he corresponded and exchanged specimens with students of these plants all over the world, paid the expenses of collectors in North America, South America and Japan, and purchased a great many specimens and a practically complete collection of the literature of Characeae, thus forming one of the most extensive accumulations of information relative to these plants which has ever been brought together. He presented all this material to the New York Botanical Garden in 1901.

Personally, Dr. Allen was a charming associate, generous to a fault, and beloved by all who knew him. His hospitality was delightful; those who participated in the Club's field excursion to Litchfield in May, 1900, will recall their experience as his guests with deep pleasure. His loss is keenly felt, both as a friend and as a scientific worker; there is now no one in America prepared to continue his studies, but we may hope that some botanist may soon be attracted to the fascinating group of plants to which he gave such close attention for many years.

Dr. Allen is commemorated by the grass *Danthonia Alleni*

Austin,* by *Eriogonum Alleni* S. Watson † and by the interesting Sundrops of eastern Long Island, *Kneiffia Alleni* (Britton) Small.‡

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NEW YORK BOTANICAL GARDEN.

Studies in the Asclepiadaceae—VII. A new Species of Vincetoxicum from Alabama *

BY ANNA MURRAY VAIL

(WITH PLATES 9 AND 10)

Vincetoxicum Alabamense

High climbing, sparingly hirsute with long rather weak hairs and a minute glandular pubescence: petioles 3–8 cm. long, channelled; leaf-blades 6–15 cm. long, 5–10 cm. broad, rather thin, ovate or oblong-cordate, acuminate at the apex, the basal auricles rounded and never overlapping, the sinus narrow at the base, sparingly puberulent and dark green above, lighter and more closely puberulent beneath: peduncles shorter than the petioles, 3–6-flowered: calyx bi-glandulose, the lobes lanceolate, acute: corolla dull greenish-yellow, 2 cm. in diameter, 5-parted to near the base; segments oval, obtuse, puberulent and minutely papillose on the outer surface, conspicuously reticulated within; gynostegium raised on a low broad column; crown orange-yellow, consisting of a low saucer-shaped ring attached to the base of the corolla, 5-parted, each division minutely and irregularly toothed or entire, appendaged within by 5 tooth-like erect crests attached to the base of the column; stigma white, flat, obtusely 5-angled: anther-tips white, scarious; pollinia obovate: ovaries minutely puberulent: follicles 8–9 cm. long, glandular-puberulent, closely and strongly muricate: seeds 8–9 mm. long, obovate, granulose, tipped by a tuft of long silky coma.

"Sandy hillsides on edge of woods," Dale County, Alabama, collected by T. G. Harbison, June 3 and September 5, 1902.

Differing from *Vincetoxicum reticulatum* (Engelm.) Heller in the greater size of its leaves and flowers, the more strongly muricate follicles and the horn-like appendages to the crown.

In *Vincetoxicum reticulatum* the leaf-blades are 3–6 cm. long, the basal sinus broad with often overlapping auricles; the racemes are mostly the length of the petioles; the flowers are scarcely more than 1.4 cm. in diameter when expanded; the crown is very obscure, and the horn-like projections of the column are also obscure or lacking.

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* Presented by invitation before the Botanical Society of America, Washington, D. C., January 1, 1903.

NEW YORK BOTANICAL GARDEN.

Explanation of Plates

PLATE 9. *Vincetoxicum Alabamense*

a. Flower enlarged, × 3.
b. Calyx (without the corolla) enlarged, × 8.
c. Sepals (showing the two glands) enlarged, × 16.
d. Ovaries enlarged, × 16.
e. Pollinia enlarged, × 20.
f. Diagrammatic transverse section of gynostegium enlarged, × 16.
g, *h*. Different aspects of the outer and inner crown (the gynostegium cut off) enlarged, × 16.

PLATE 10. *Vincetoxicum reticulatum*

a. Flower enlarged, × 3.
b. Calyx (without the corolla) enlarged, × 8.
c. Sepal (showing the solitary gland) enlarged, × 16.
d. Ovaries enlarged, × 16.
e. Pollinia enlarged, × 20.
f. Diagrammatic transverse section of gynostegium enlarged, × 16.
g, *h*. Different aspects of outer and inner crown (the gynostegium cut off) enlarged, × 16.

A new Species of Waldsteinia from Idaho.

By C. V. Piper

Waldsteinia Idahoensis

Caudex short, stout, covered with the flattened bases of old petioles : leaves orbicular, some of them faintly 5–7-lobed, cordate, coarsely and doubly crenate-dentate, glabrous beneath except near the sinus where viscidulous, sparsely pilose above and ciliate, 2–5 cm. broad ; petioles nearly glabrous except at the broadened base where pilose-ciliate, two or three times as long as the blades ; stipules obsolete : scapes one or several, 10–25 cm. high, glabrous or nearly so, naked or with one or two lanceolate or auriculate-lanceolate ciliate bracts, 5–15 mm. long : inflorescence glandular ; cyme open, bearing 2–7 flowers, or rarely but one ; bracts lanceolate or ovate, some of them clasping at base, ciliate, 2–6 mm. long ; pedicels spreading, somewhat cernuous, 5–20 mm. long : calyx-lobes ovate-triangular, acutish, minutely glandular, 5 mm. long : petals yellow, orbicular, equalling the calyx-lobes : akenes two (always ?), oblong, obtuse, canescent, 2.5 mm. long.

Collected July 31, 1902, on the Lochsa River at the mouth of Lempke's Creek, Bitterroot Forest Reserve, Idaho. The specimens are mostly past maturity, only one flower being found, and but two specimens from which the akenes had not fallen. The plant is evidently very local as it was seen at no other place, though quite abundant over a few acres where found. Mr. J. B. Leiberg, who has botanized quite extensively in the Bitterroot Forest Reserve, writes us that he has never met with this plant.

This species is quite closely related to the extreme South-Alleghanian *Waldsteinia lobata* T. & G. It differs, according to Mr. Greenman, who has kindly compared the two species, in its glandular inflorescence and in being less pubescent on the under side of the leaves and on the petioles.

The curious distribution of this third American species as compared with its nearest relatives deserves comment, especially as a number of other plants show somewhat similar relations. Among them the following come to mind :

Pachistima myrsinites Raf. is common in the mountains at low elevations from British Columbia to New Mexico. The only other species, *P. Canbyi* Gray, is confined to one or two localities in the mountains of Virginia.

Spiraea lucida (Dougl.) Greene ranges from Alaska to Oregon and Wyoming and eastward to the Black Hills. It seems to me identical with the Alleghanian *S. corymbosa* Raf., the distinctions pointed out by Professor Greene (Pittonia, **2**: 221) not holding good. Indeed, both supposed species are exceedingly close to if not identical with *S. betulaefolia* Pallas.

Trautvetteria grandis Nutt., of Idaho, Washington, Oregon and British Columbia, is very similar to the other American species *T. palmata* F. & M., of the southern Alleghanies.

Boykinia occidentalis T. & G., of the coast region of Oregon and Washington, is the nearest ally of *B. aconitifolia* Nutt., of the southern Alleghanies. All the other known species are Pacific.

Rhododendron Californicum Hook., of the Cascade and Coast Mountains, in Washington, Oregon and North California, has no close relatives nearer than the Alleghany Mountains.

Xerophyllum tenax (Pursh) Nutt. ranges from British Columbia to western Montana and middle California. Its Atlantic congener *X. asphodeloides* Nutt. occurs from New Jersey to Georgia.

Of the significance of these examples the writer has no opinion to hazard. They are sufficiently curious, however, to deserve attention being called to them.

PULLMAN, WASHINGTON.

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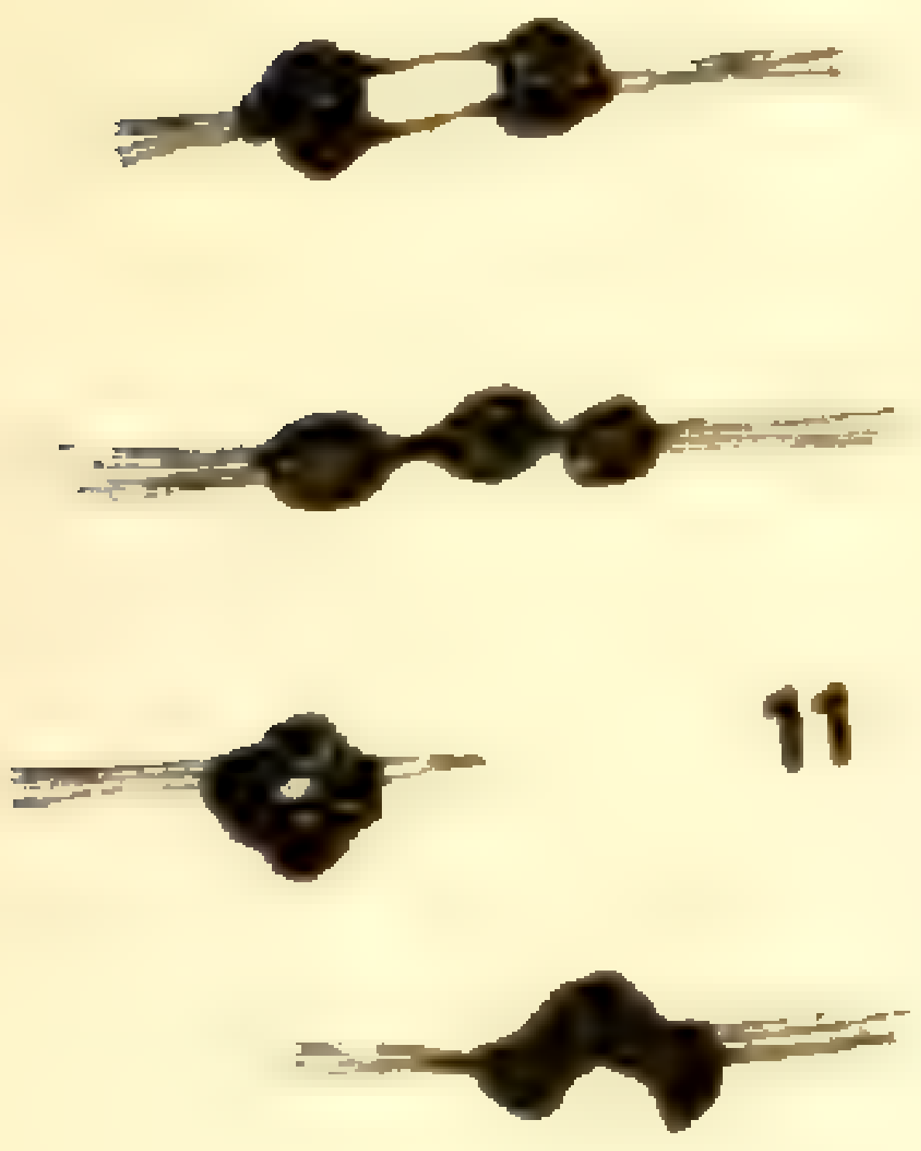
SPERMATOGENESIS OF HYBRID COTTON.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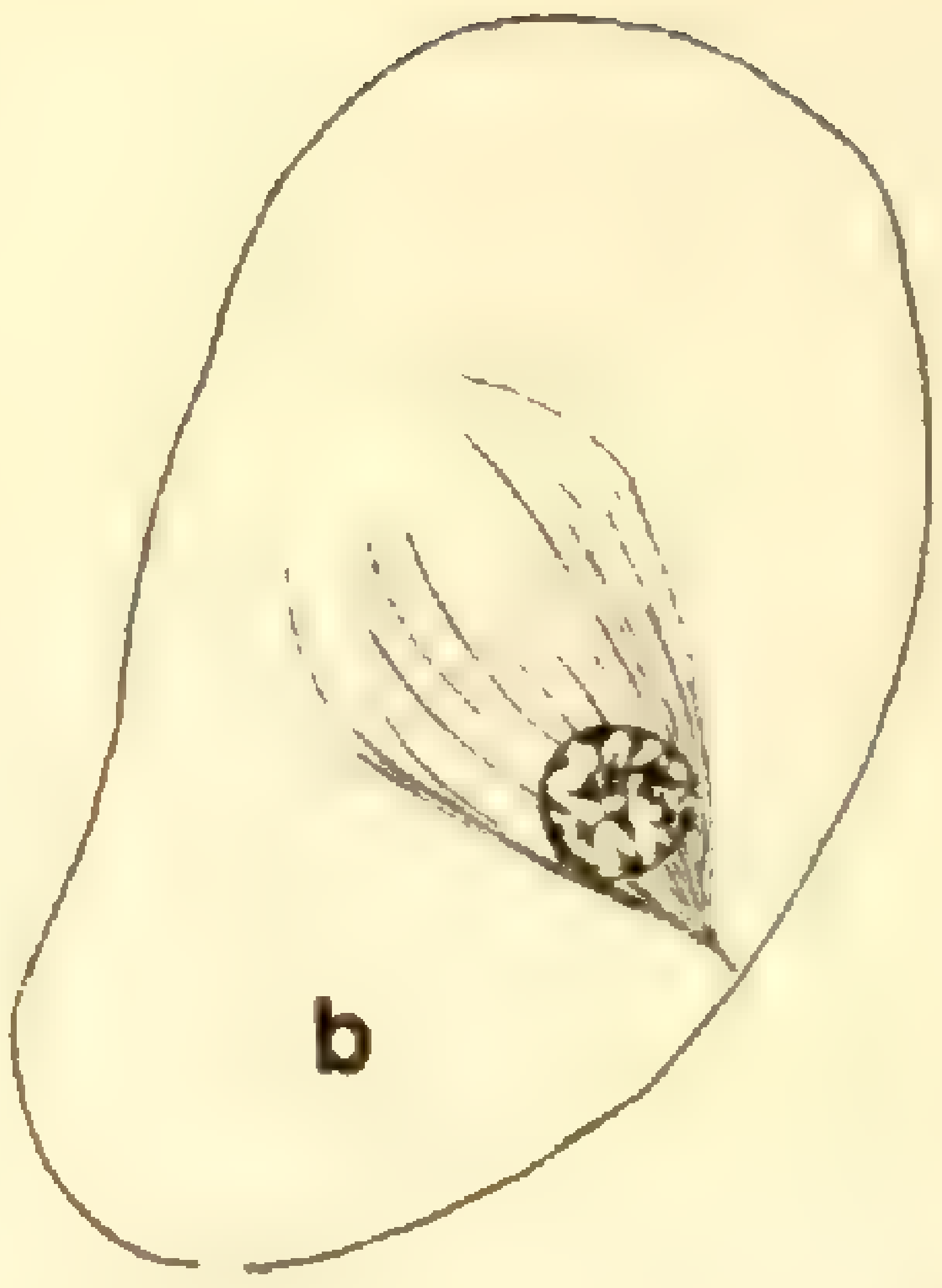
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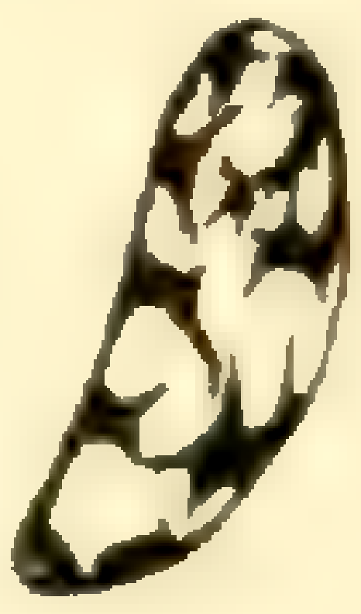
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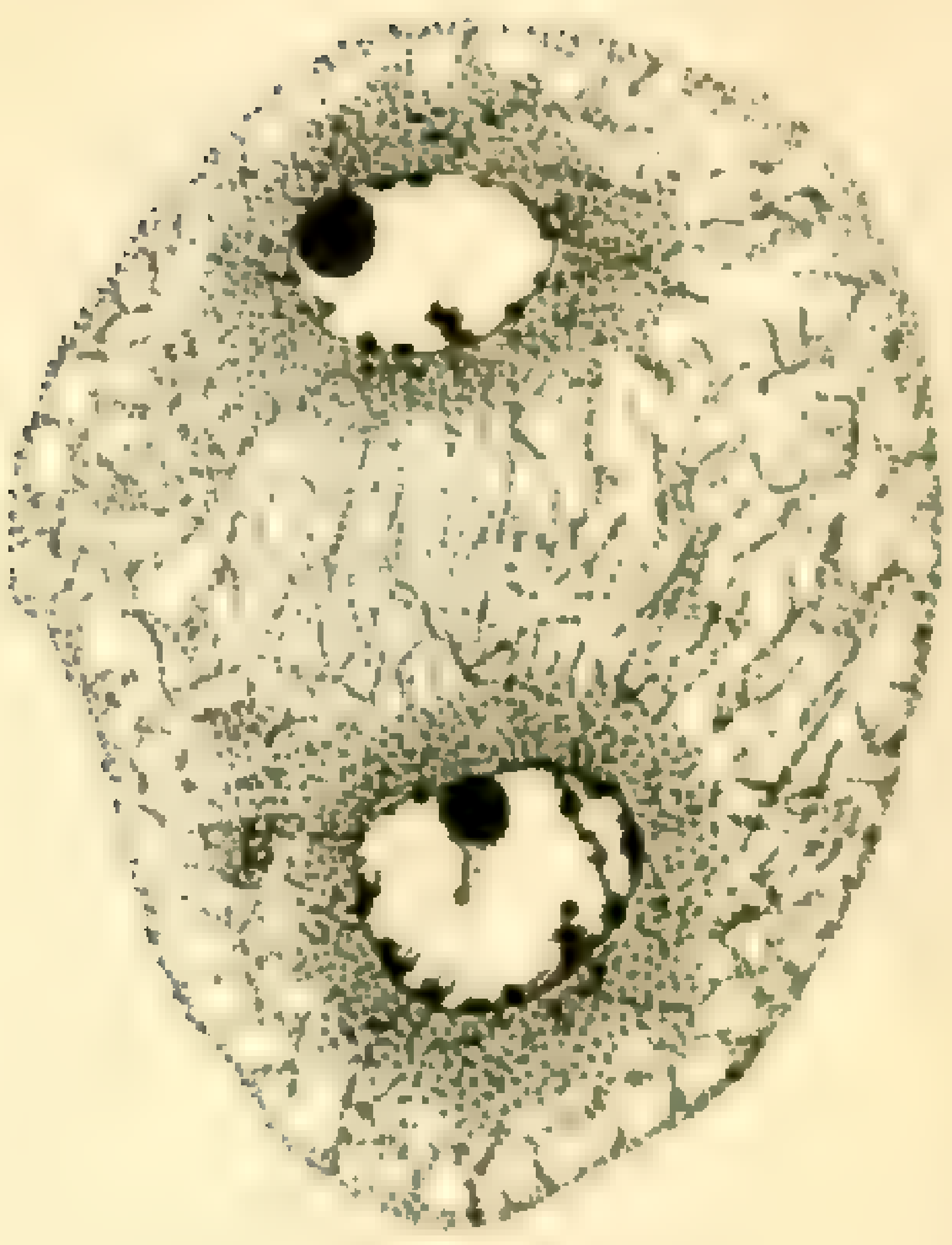
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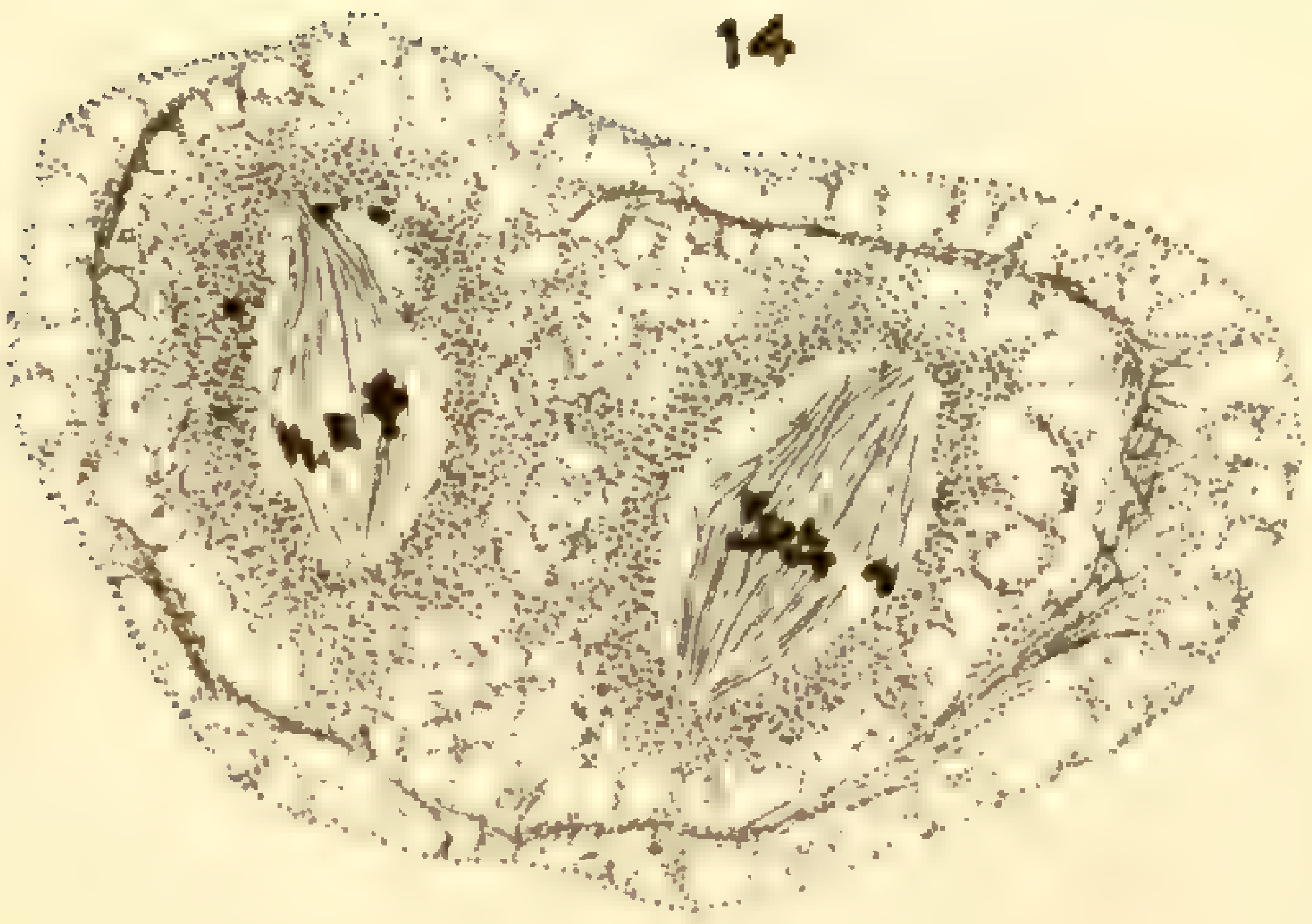
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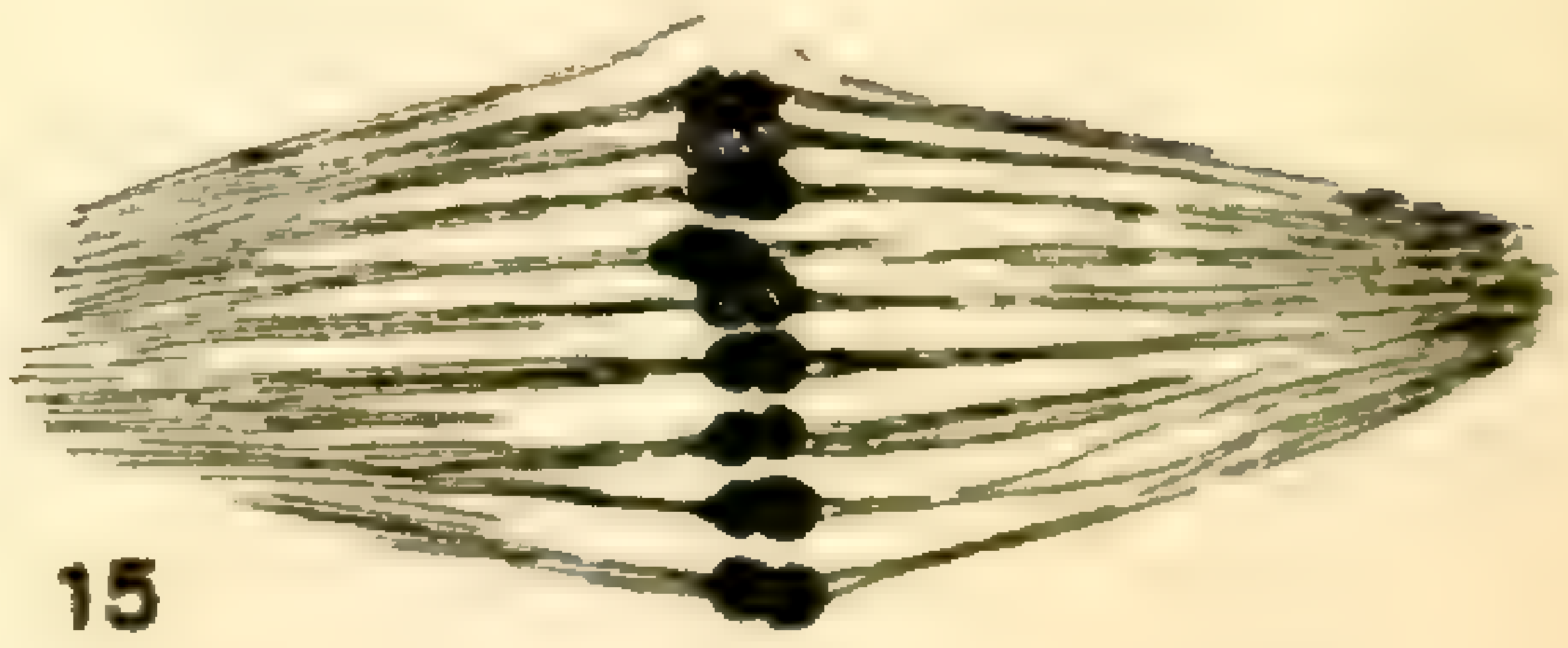
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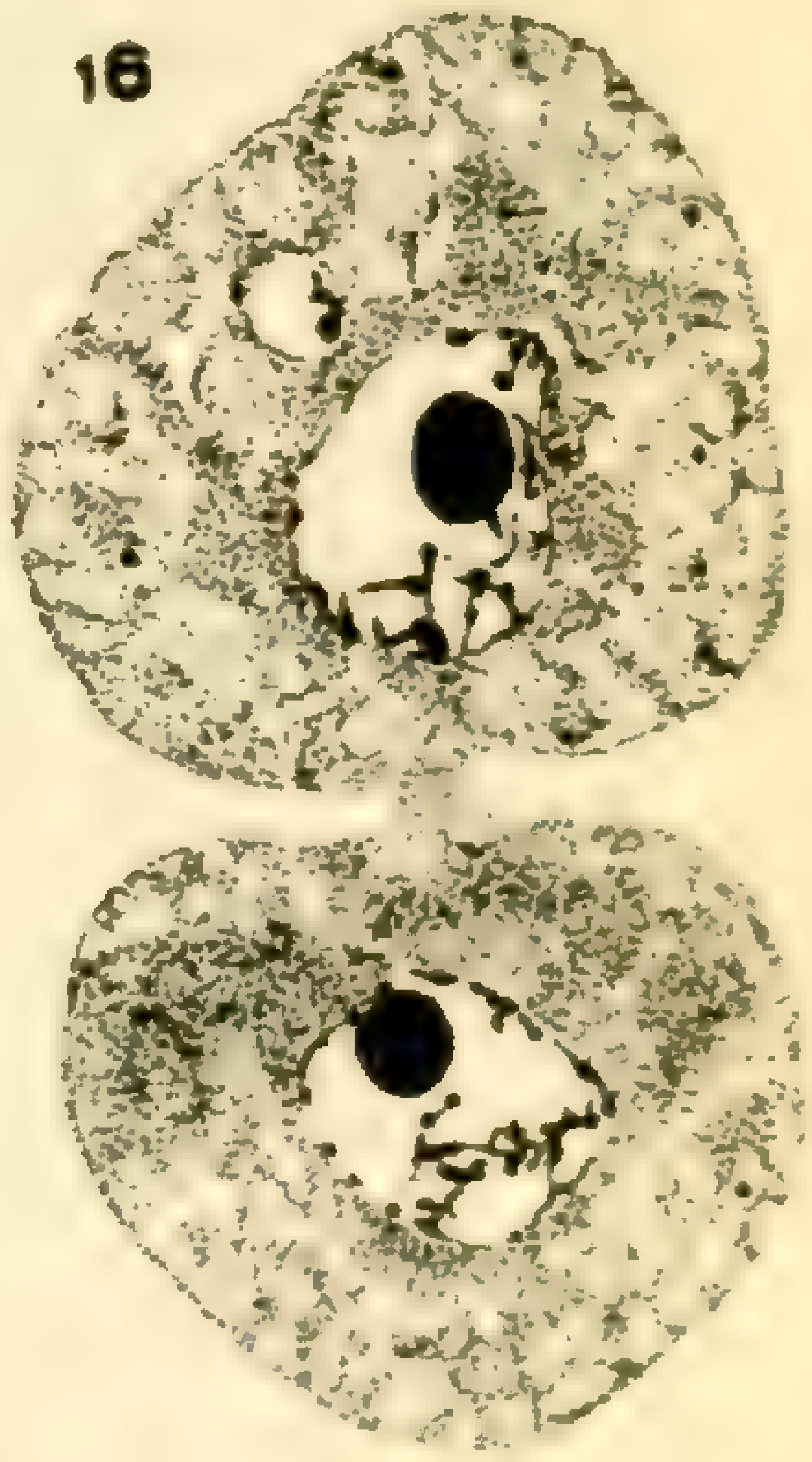
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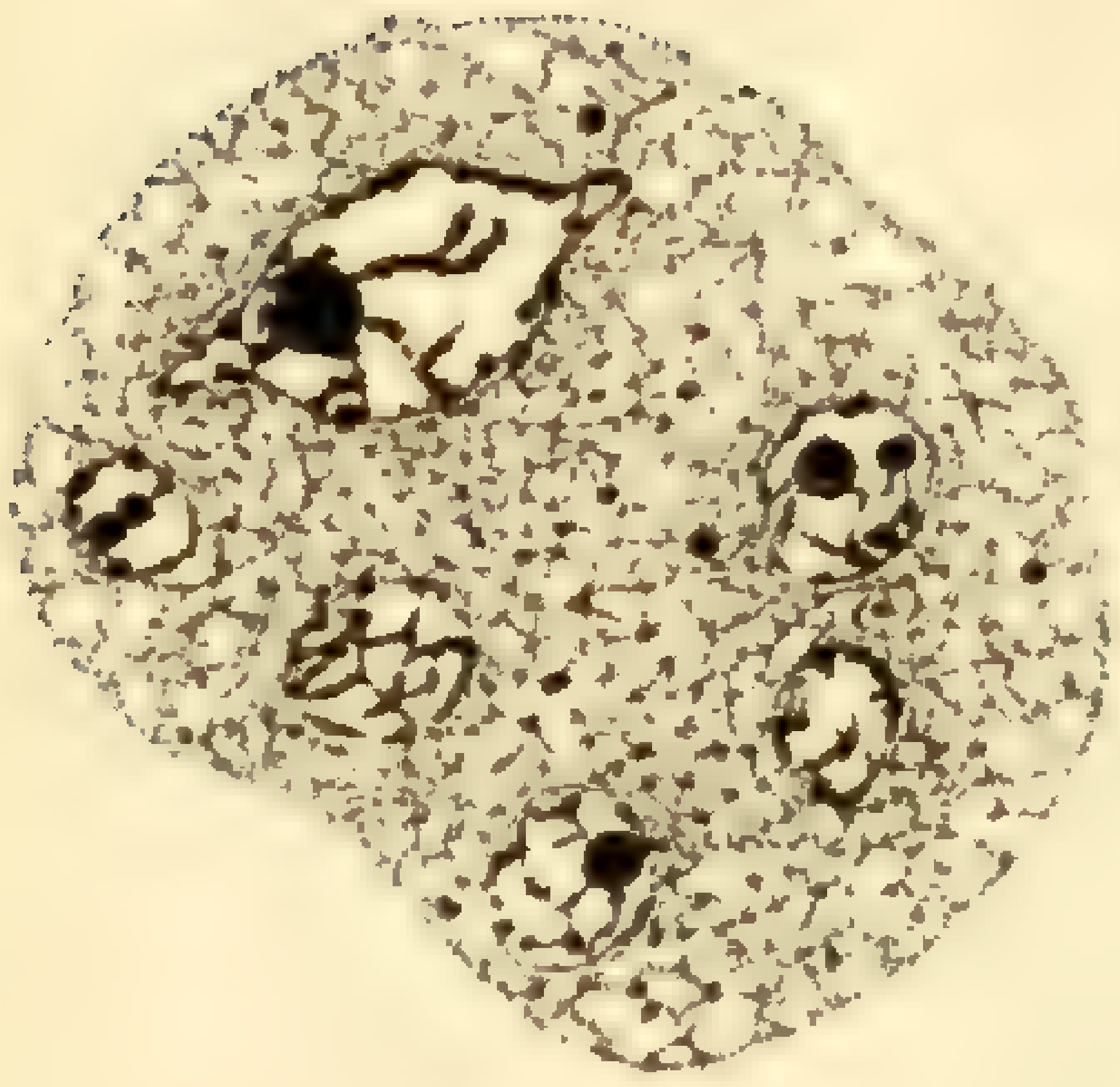
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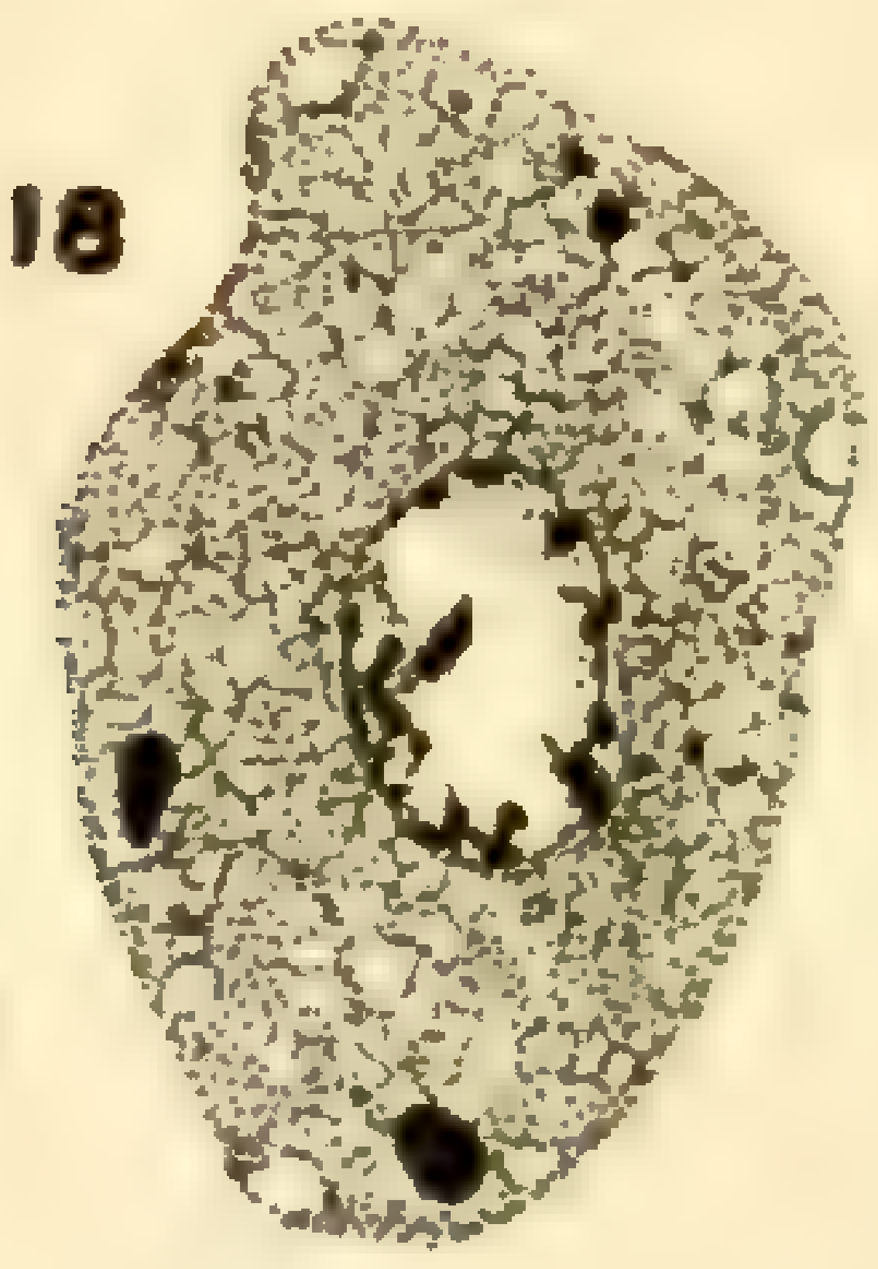
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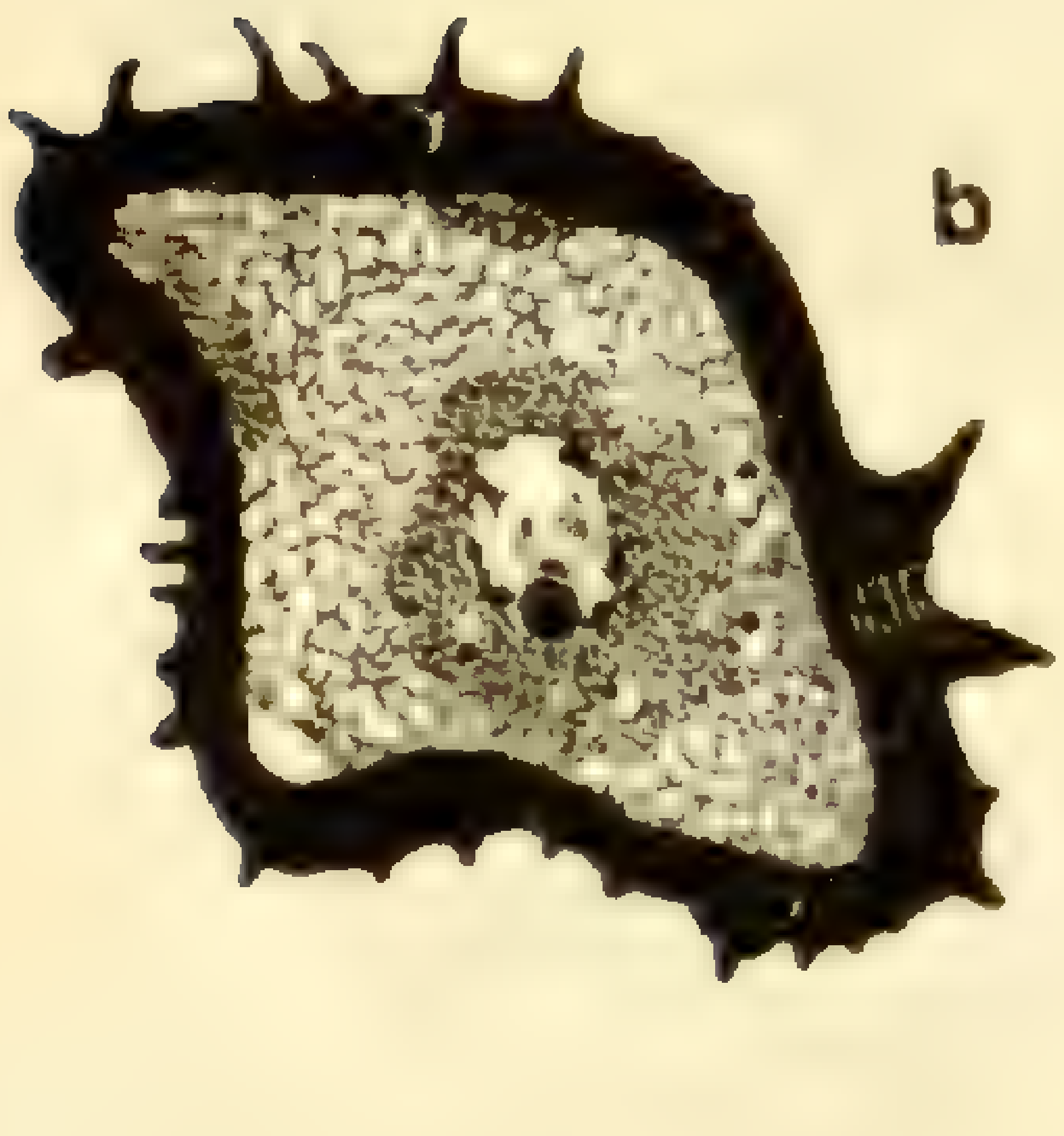
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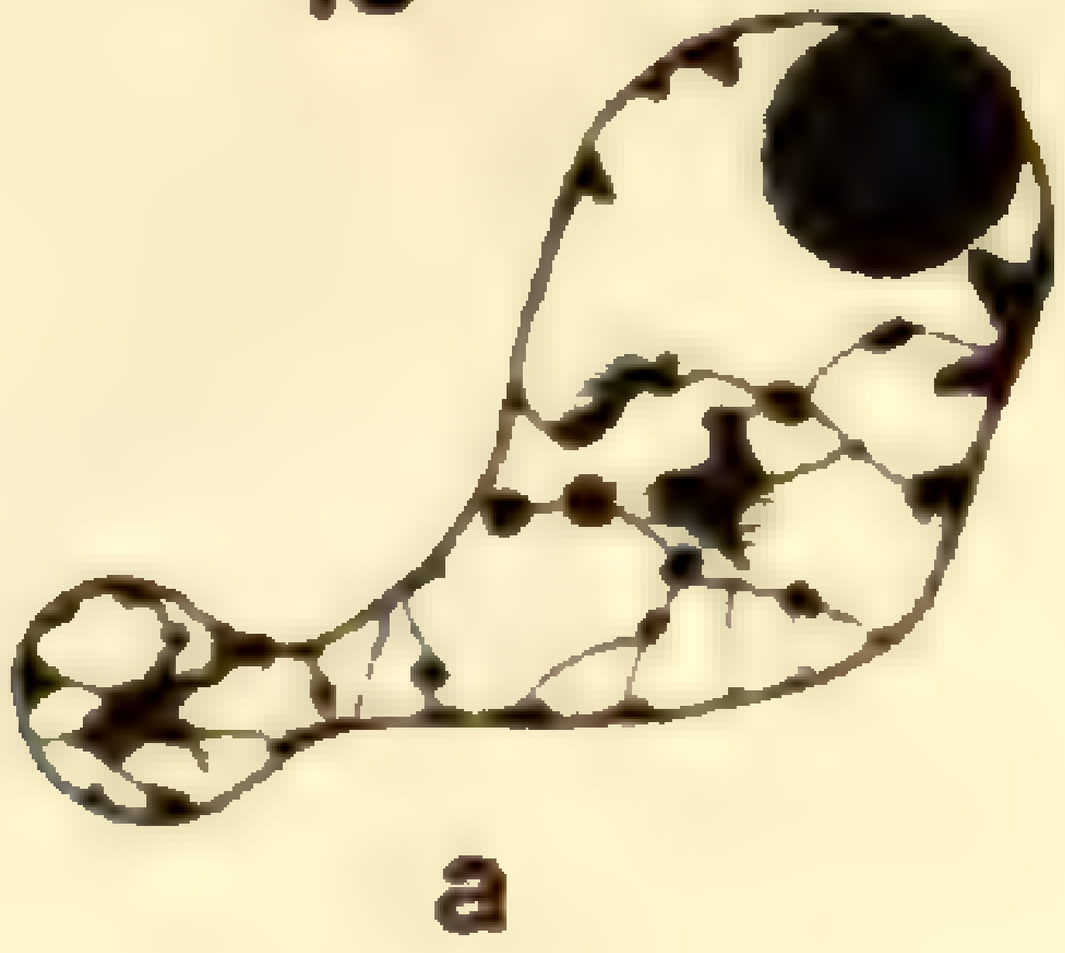
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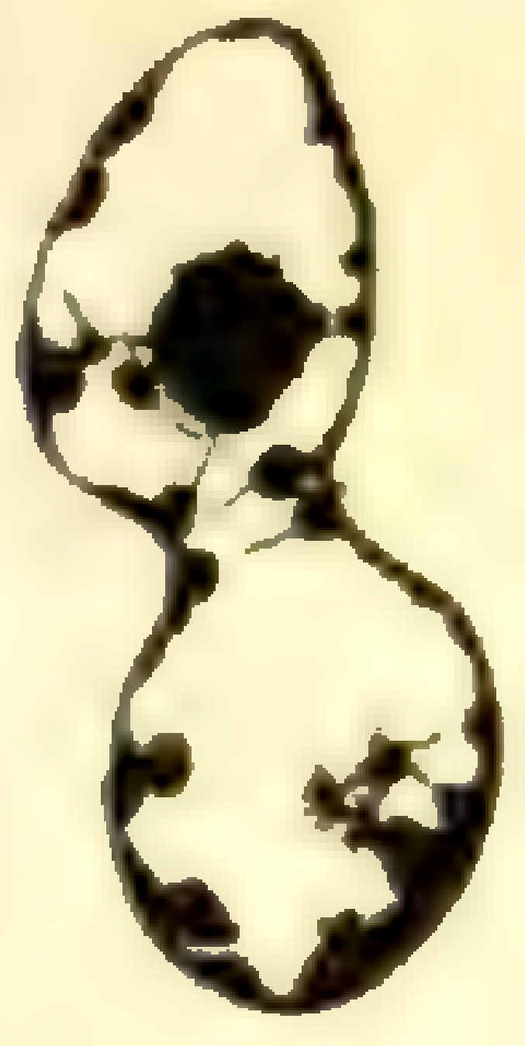
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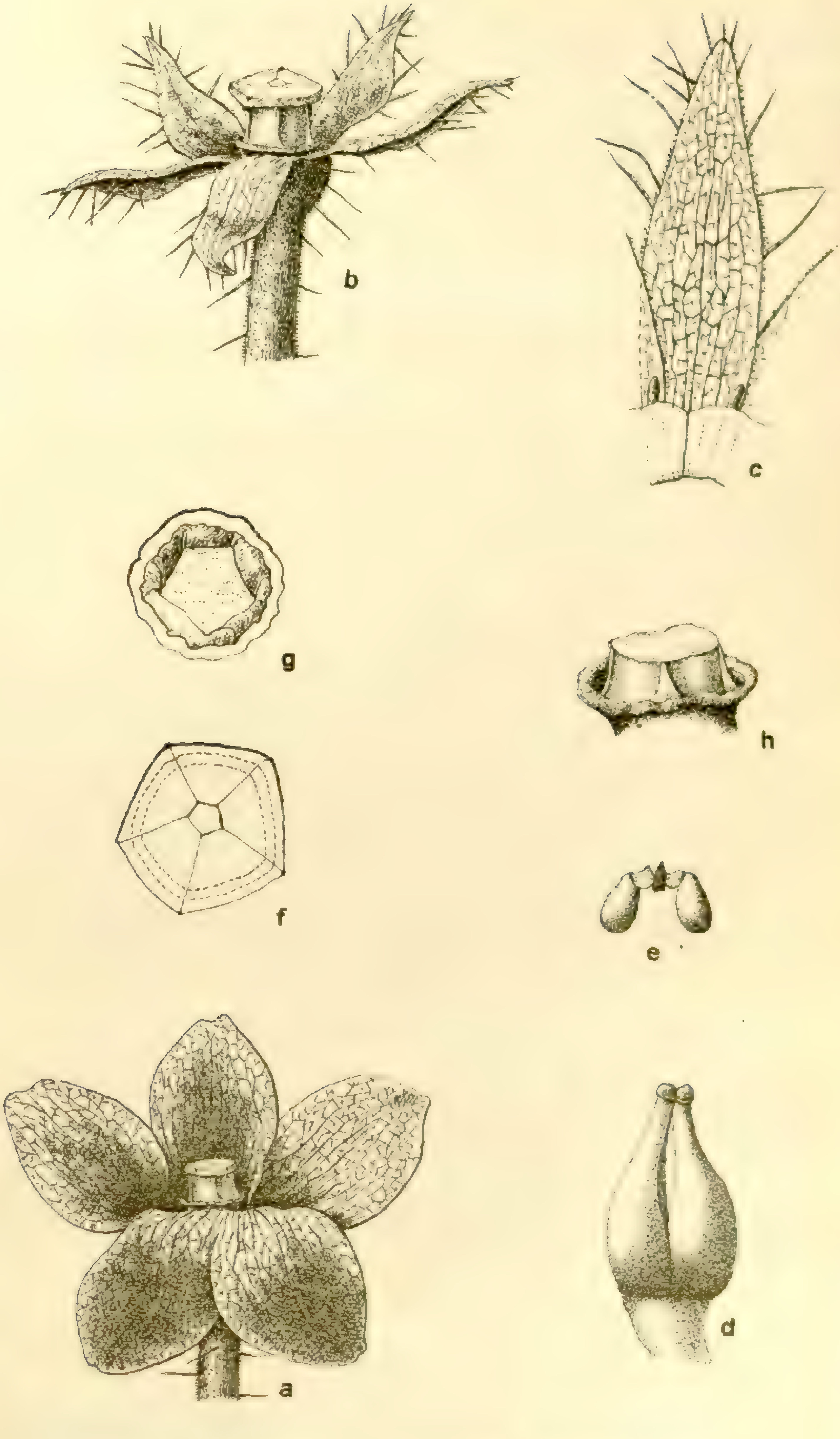
SPERMATOGENESIS OF HYBRID COTTON.

VINCETOXICUM ALABAMENSE Vail.



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BULLETIN

OF THE

TORREY BOTANICAL CLUB

APRIL, 1903

Regeneration in Plants*

BY KARL GOEBEL

The phenomena of regeneration in plants have been known much longer than those in animals. For cuttings of twigs and the separated leaves of many plants to become independent individuals, or to give rise to them, is an every-day occurrence. The anatomical changes which take place are, in general, well known. On the other hand, relatively few investigations have been made as to the factors which set up regeneration and determine the kind of organs and the manner of their formation in regeneration. It is evident without further discussion that a knowledge of these facts would be of the greatest importance for every theory of organic development and heredity, and in brief for all investigations which might be classed under "causal morphology." It is necessary to group the facts from some general point of view before a theory can be formulated. I have already attempted this some time since, and will give in the following a brief restatement of the conclusions already reached together with the results of some new experiments. It will be profitable to repeat some of my previously formulated propositions † in a somewhat modified form.

1. The phenomena of regeneration imply a development of dormant or latent rudiments. These rudiments (*Anlagen*) are present as vegetative points (embryonic tissue) and are set into

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*Read by invitation before the Botanical Society of America, at Washington, December 31, 1902.

† Goebel, K. Ueber Regeneration im Pflanzenreich. Biol. Centralb. 22: 385–397, 417–438, 481–505. 1902. See also discussion and literature in Goebel, Organographie der Pflanzen, 35–43. 1898.

[The preceding number of the BULLETIN, Vol. 30, No. 3, for March, 1903 (30: 133–196, *portrait, pl. 7–10*), was issued 8 Ap 1903.]

activity by injuries, or they are outwardly invisible, there being simply a disposition or tendency toward the formation of new structures, as in adventitious buds, or adventitious roots. The two cases are not sharply distinguishable from each other, since in both the unfolding of a rudiment, or the awakening of a predisposition, is conditioned by the reciprocal connections of organs with one another, which are designated as "correlations."

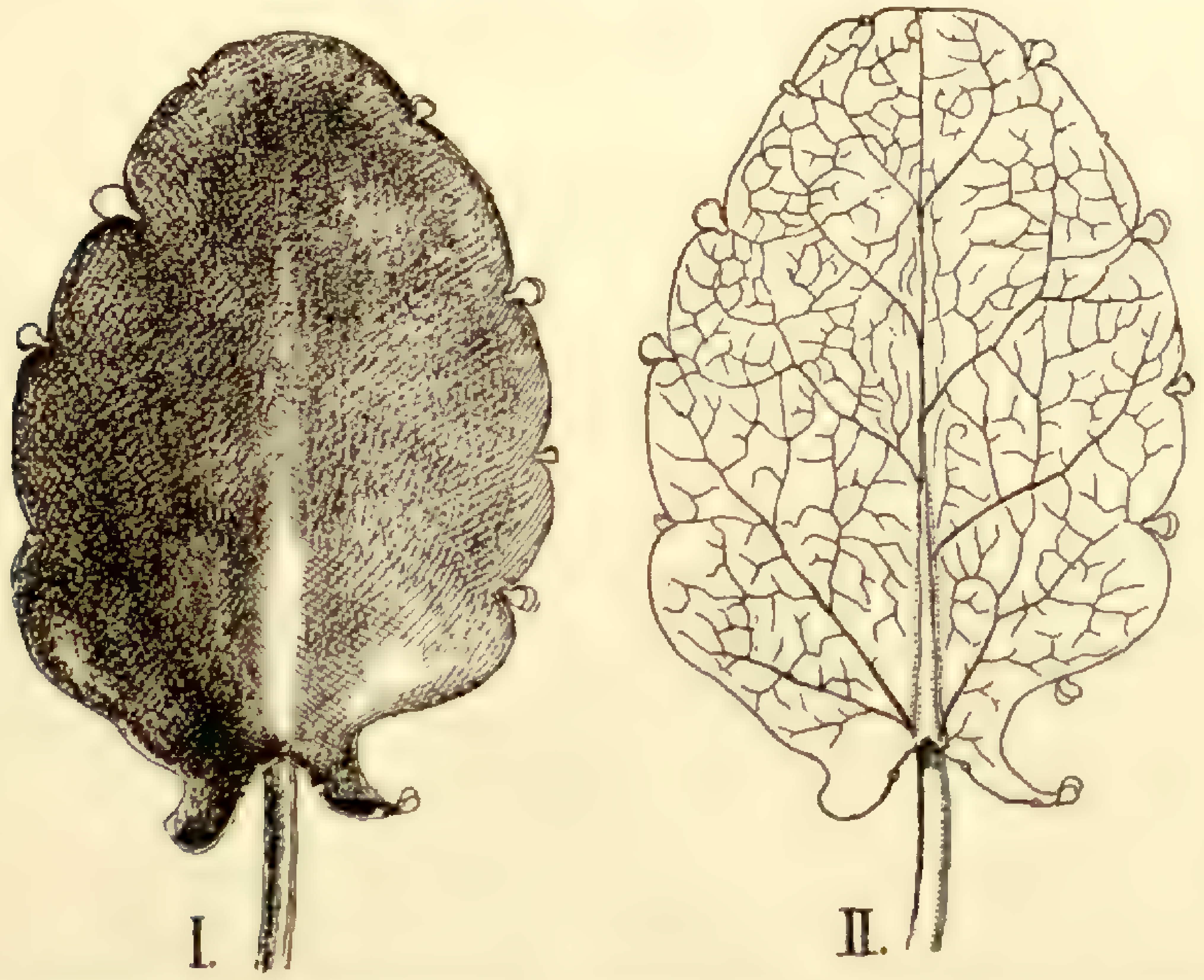

Fig 1. *Bryophyllum crenatum.* Detached leaf, which has developed sprouts upon its edge, each with two small leaves. (In II made translucent so that the venation is visible.)

Some examples will make this point clearer. It is well known that every tree has hundreds of dormant buds which ordinarily do not awake, but which may be set into activity by cutting back, or by the destruction of the leaves during the vegetative season. My investigations were most closely concerned with the development of the buds which are normally present on the leaves of some Crassulaceae, as for example *Bryophyllum crenatum*, and which are laid down even in the embryonic condition of the leaves. Their presence implies that the leaves here serve the function of reproduction, since every leaf that is cut off, if laid in damp earth, produces numerous young plants in the notches of its edges.

The next question to be considered is by what means the development of the shoot-rudiments existing on the leaves is set in action. Investigation showed that this development may be induced by cutting the larger vascular bundles, and also the veins of the leaf. The leaf remains fresh and attached to the plant, but becomes covered with young sprouts through the growth of the rudiments on the edge of the leaf. We see by this that a disconnection, or interruption of the conducting system gives the stimulus for the further development of the resting vegetative point on the leaf; but why this interruption should act as a stimulus has not yet been explained. Further investigations may throw some light upon this point. The vegetative points were removed from a number of plants except those found on the margins of the leaves. The result of this operation was that the vegetative points which usually remain dormant became active. The conductive system was not broken but the goal of the system was removed in a manner. For the vegetative points are to be considered as centers of attraction for the constructive material which is carried thither to be used in the building up of new organs. We can say, therefore, that the presence of the vegetative points on the shoot prevents the development of those on the leaves. The former lay claim to the conducting channels that run through the leaf, and only when these are broken or the vegetative point of the shoot is removed do those on the leaves develop. A correlation is clearly apparent.

Whether we have to do in this case with a quantitative relation to constructive material, as was assumed above for the sake of simplicity, or with imperfectly understood specific reactions to stimuli along the conducting system must for the present remain unsettled.

It appeared of interest to me to determine the behavior of plants that have no vegetative points on the leaves, but possess only the tendency to construct adventitious shoots from cells which have passed over into permanent condition. The best known example of this is *Begonia Rex*. Florists propagate this plant by setting leaves cut from the stems in damp sand. At the base of the blade adventitious shoots appear; and one can easily induce them to appear on other places by cutting the larger veins of the leaf.

If the above proposition is correct, it would necessarily follow that we could induce the development of these adventitious shoots on leaves as well, which still retain their connection with the plant. If the attempt were to prove successful, we should have induced experimentally in *Begonia Rex* a phenomenon which is normally characteristic of two other species of this genus. Systematists state that in *B. sinuata* and *B. prolifera* both leafy and flowering shoots develop on the leaf-blade and even from its base.

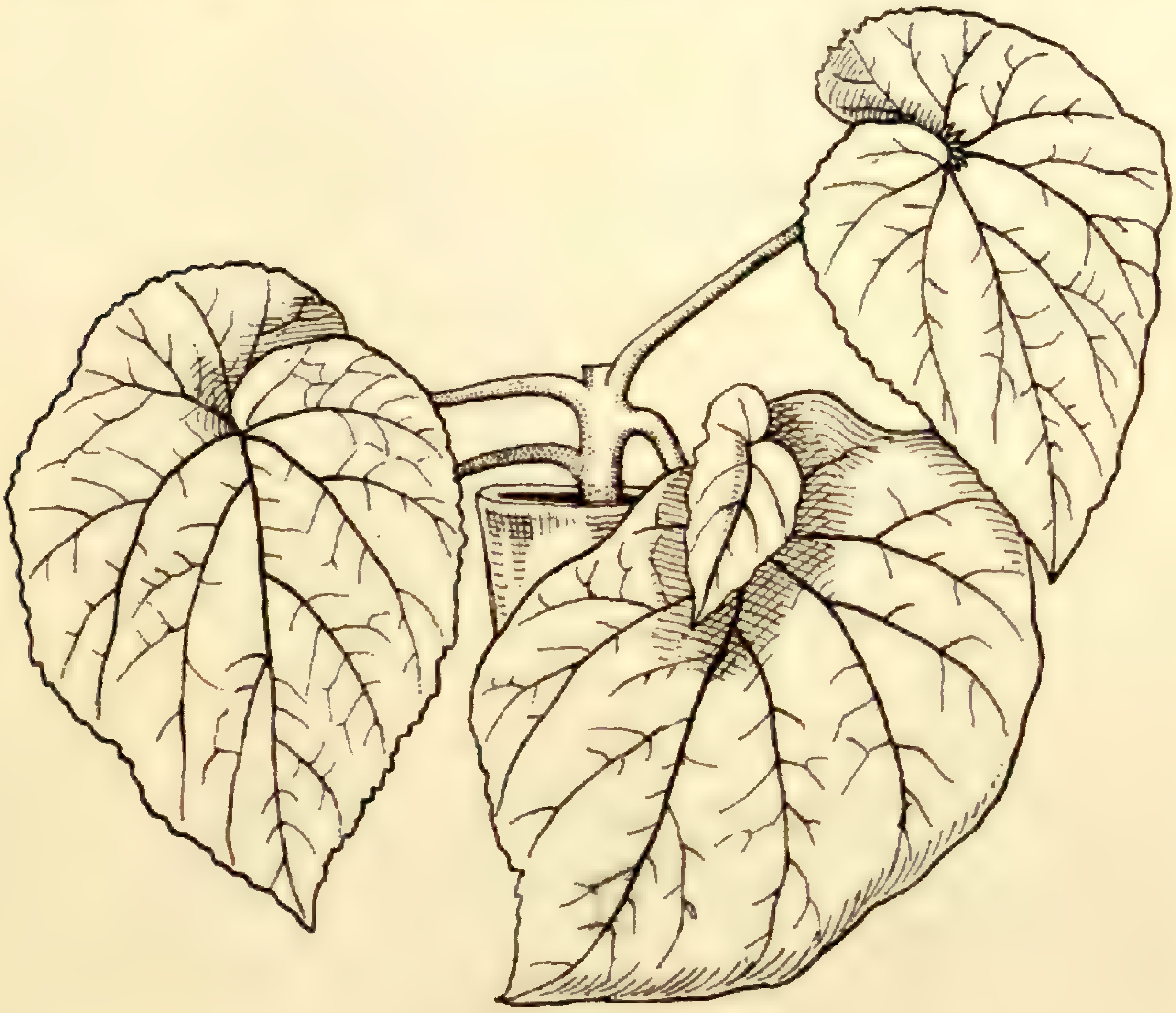

FIG. 2. *Begonia Rex.*

It was found possible to induce the production of shoots on the leaves, as shown in *f. 2*, although not, it is true, as quickly as in *Bryophyllum.* The method used was the same as in the previous instance. All vegetative points that could be found were removed. The plants soon began to develop dormant buds that had been hidden, and produced adventitious shoots in the axes: all these shoots were removed and the process was repeated. After about three months, there appeared on the leaves of the plants treated in this manner adventitious shoots which developed into plants. The shoots came from the bases of the leaf-blades, where the large veins join. Here then we have the same phenomenon as in *Bryophyllum:* that is the removal of the vegetative points of the shoots starts the development. In this case, however, we have to do, not with previously laid-down primordia, but with a disposition on the part of the tissues of the leaf; and we have actually brought about a form-relation present in other species but normally absent from *Begonia Rex*.

2. When a part of a plant is removed direct restoration occurs only when we have to do with embryonic tissue, such as that of the vegetative point. When parts of plants which have assumed their permanent character are concerned the rupture and wounding have the effect of inducing a portion of the cells to return to the embryonic condition and to produce structures which give rise to one or more new plants. Many seedlings have a remarkable power of regeneration.

There is no important and invariable difference in the phenomena of regeneration in plants and in animals, but the course of procedure that has been described is highly characteristic of plants. While in animals the parts that have been lost must be replaced directly, this is the exception in plants. A few illustrations will make this clearer.

(*a*) Embryonic tissue. It has long been known that vegetative points of roots and shoots, if wounded, easily regenerate what has been lost. Fern-fronds have, as is known, the peculiarity that the tip remains in an embryonic condition for a long time, while it soon passes into permanent form in most spermatophytes. I split young leaves on *Polypodium Heracleum* lengthwise into two similar or dissimilar halves. When the parts were alike the tips of each regenerated a perfect leaf; when the parts were unequal, the regeneration on the smaller was much less marked. Similar phenomena are to be observed in the tips of roots or shoots.

(*b*) On the other hand when the parts of a leaf which have assumed permanent form are removed, the restoration does not take place; a separated leaf of *Begonia* for example does not regenerate a new shoot-axis with roots which continue life as a part of the regenerated plant, but there develop on the leaf new plants which soon become entirely independent of the original leaf. The cells of the leaves of many plants are easily induced to develop new plants; they contain all the necessary germ-plasm, but are not in a position to coöperate with one another in such manner as to directly replace what was lost by newly constructed tissues.

The one exception to the above established by Hildebrandt, Winkler and others is the case of first leaves of the seedlings of *Cyclamen Persicum.* When one removes the leaf-blades in this plant there develop to the right and left of the petiole new blades. But in this case also, as I think I proved, there is only a development of latent rudiments. From the point of view of embryology, the leaf-stalk is a part of the leaf-primordium, in which the development of the leaf-blade is arrested. This condition of arrest is by no means so well established in the seedling as it is in later stages, and consequently it can be overcome. When the blades are removed from leaves in older plants these organs die without forming new blades.

Similar conclusions were arrived at in all cases in which a critical examination was made. The phenomena of regeneration in leaves, as described in the literature of the subject, will not bear careful examination. On the other hand, it can be shown that seedlings often possess a greater capacity for the formation of new organs than older plants. Not a few seedlings develop adventitious shoots on the hypocotyl even without being wounded. Such shoots have also been seen on the leaves of young plantlets of *Lycopodium inundatum,* but not on those of older plants.

3. The character of the organ constructed depends upon the condition of the plant at the time regeneration ensued. Illustrations of this fact are quite as apparent in the lower as in the higher plants. The fungi may be cited first. From investigations by Van Tieghem and Brefeld we know that when, for example, the pileus of certain agarics is cut off, there is a regeneration from the stalk, not of a new pileus, but of one or more complete fruiting bodies. We see here that a direct restoration of the part that has been lost does not take place, but the new organ is dependent upon the condition of the plant, in that as a result of the wound, the mycelium proceeds immediately to build up a new fruiting body, and does not go through a longer vegetative period.

It is to be remembered that the dependence of the formation of organs upon external conditions is much greater in fungi than in the higher plants. If the sporangium is removed from the fruiting hypha of *Phycomyces* there is developed a new fruiting hypha from the stalk of the old one. But when regeneration takes place on an entirely immersed fruiting hypha the external factors influential in the production of fruiting hyphae are lacking and a vegetative hyphal branch developes. It appears therefore that the above-mentioned relation generally holds good.

Formerly I believed that in certain cases in fungi a direct restoration of wounded fruiting bodies could take place. I cut pieces from the fruit of *Stereum hirsutum*, and found after some months, growth being slow in this instance, that the bodies had reassumed somewhat the shape of the fruit before wounding. Closer investigation showed that this was not the case however. The fruit-body exhibits a characteristic zonal formation (*f. 3*). The new formation does not in any way add to the zone formation of the old fruit-bodies but is entirely independent of it (*f. 4*).

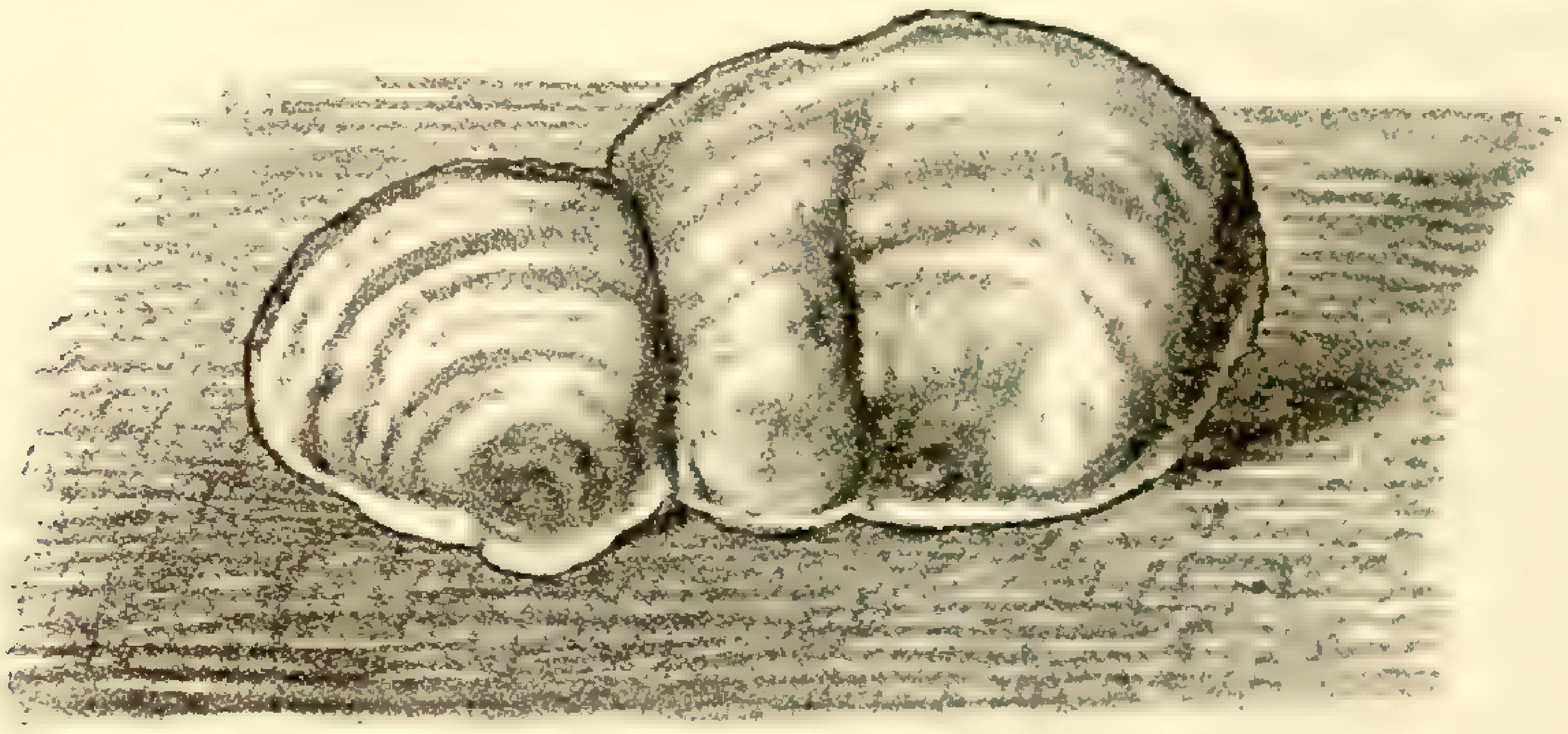

FIG. 3. *Stereum hirsutum.* Fruit-bodies from beneath.

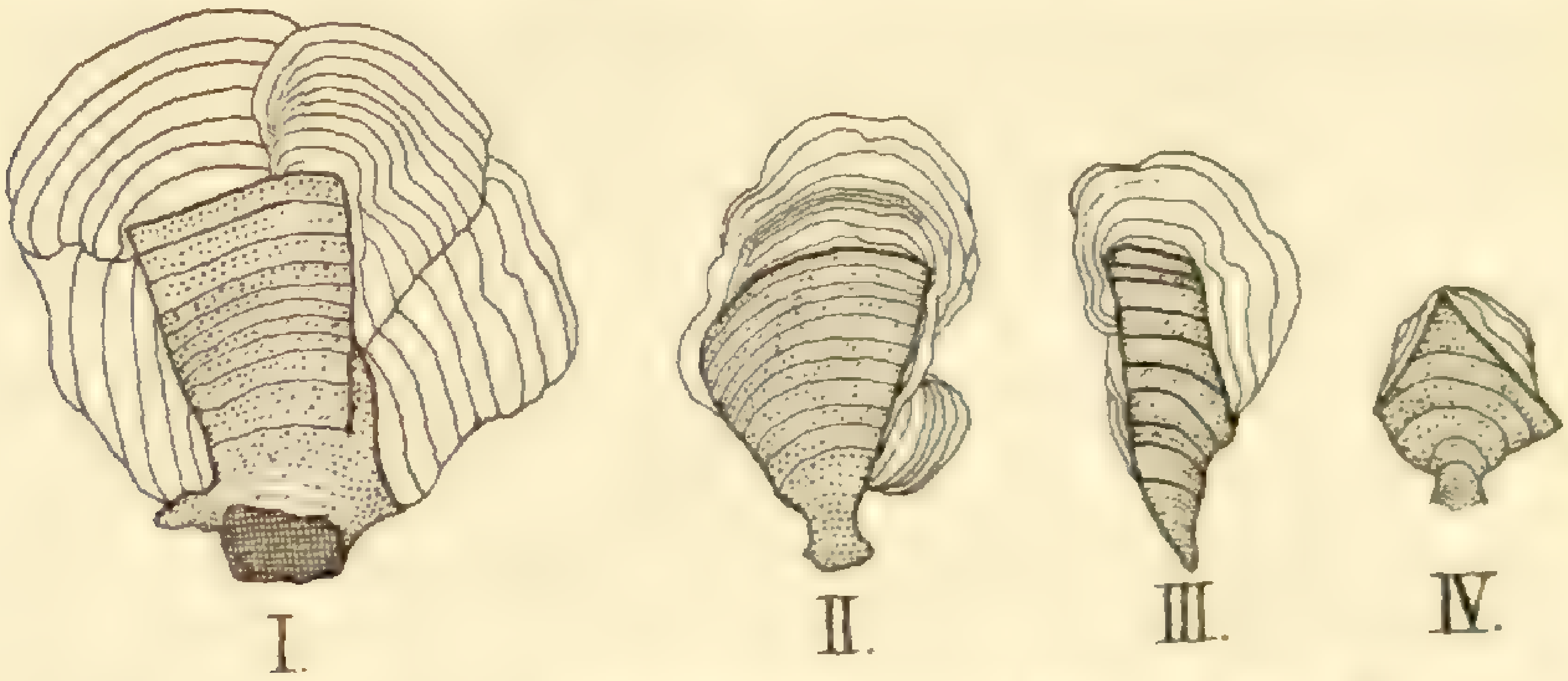

FIG. 4. *Stereum hirsutum.* Regeneration of the fruit-bodies. The old portions are dotted.

They are actually new fruit-bodies, but since they are scarcely individualized they soon grow together with the old fruit and so appear as regenerated parts of the latter. Injured fruit-bodies growing in close proximity often become concrescent and so show that the above conclusion is correct.

Among higher plants *Begonia* is a good example. When parts of leaves are taken from plants of *Begonia Rex* in a flowering condition, these proceed to the formation of flowers much more quickly than those parts taken from plants not in flower (Sachs), and in *Begonia discolor*, which forms bulbils in the autumn, we get leafy shoots as regenerated organs in the spring, but bulbils in the autumn (Wakker).

I have cited other examples of this relationship, which forms an important part of the theory of metamorphosis, in another place.

4. The character of the organs formed in regeneration is dependent to a very slight degree only on outside factors. It is conditioned by the structure of the parts of the plants concerned, particularly by the direction in which the constructive material moves ; the wound-stimulus must also be taken into consideration.

Vöchting's well-known investigations have directed the attention of botanists to the polarity apparent in regeneration. New shoots are produced at the tips of old shoots, and roots from the bases. This process is reversed in root-cuttings. Leaves show no polarity in regeneration ; the new organs appear at the base. The cause of these differences is the next point to determine. Vöchting held that above all *difference in growth* was the determining factor. Organs which have limited growth show regeneration at the base ; those which have unlimited growth show polarity.

I can not agree with this conclusion. The relations described above are the ones which, in my belief, are to be considered most important. In a foliage leaf the constructive materials are in the process of movement toward the stem. When we cut off the leaf, the new organs are in accord with the above idea produced at the base. In shoots and roots we have a double movement : on the one hand toward the vegetative point of the shoot, and on the other toward the vegetative point of the root. This implies the existence of polarity in these instances.

Space does not admit the citation of all of the facts bearing upon this point, but a few examples may be mentioned. If Vöchting's theory were correct, *all* organs of limited growth would necessarily show similar relations. But this is not the case. The leaves of the foliaceous liverworts do not show any tendency to limit regeneration to the bases. This however is easily explainable from my point of view. These leaves are composed of only one or two layers of cells and so have at the time of separation neither a very large amount of constructive materials, nor definite conducting systems to carry them. They form adventitious shoots only when, after being cut off, they have been able to perform the photosynthetic processes for some time. No cause exists for the limitation of regeneration to the base of the leaf. The pieces from the flanks of the thallus of *Fegatella* behave similarly.

On the other hand the leaves of *Bryophyllum* produce, in general, no new structures of their own when cut off, all of the constructive material being used by the vegetative points already in existence in the indentations. The removal of these on a number of leaves caused the formation of roots at the base of the leaves, and in one instance of a bud also. These facts seem to lead to the conclusion that:

1. The vegetative points serve as centers of attraction for the constructive material necessary for the formation of new organs.

2. As long as the leaf remains attached to the stem the materials flow into the stem; when the leaf is detached, the materials are appropriated by the vegetative points of the leaf.

3. The removal of the vegetative points of the leaf is followed by the transfer of the place of origin of new structures to a point down the conducting tracts at the base of the leaf.

The above are the chief conclusions so far attained, but much more research will be necessary before the processes of regeneration are well understood.

MÜNICH, November 15, 1902.

[This paper was written in German; the English translation, which was read at Washington and is here printed, while authorized by Professor Goebel, has not been revised by him.—ED.]

The Hypothesis of Formative Stuffs*

BY T. H. MORGAN

It is with some hesitation that I venture to discuss the hypothesis of formative stuffs as used by Professor Goebel in his Organographie and in his recent papers in the Biologisches Centralblatt. But since for all questions connected with the regeneration of plants it is of great importance to have a clear understanding of what this hypothesis really means, I hope that I shall be justified in entering into a discussion of this question, although the hypothesis is applied by its present adherents rather to plants than to animals. Professor Goebel uses the word correlation to give a name to certain curious, connected changes in different parts of the plant. Almost without exception when he ventures to express an opinion as to the cause of this connection, he makes use in one form or another of the Bonnet-Sachs hypothesis of formative stuffs. These stuffs are imagined to be either organized or unorganized substances that flow in different directions. The cause of this flow is sometimes ascribed to the polarity of the tissues; at other times to the attractive power for such substances that certain parts are supposed to possess. These alternatives are, I believe, fundamentally different conceptions.

I have made bold to question this hypothesis of formative stuffs.† More especially in the case of animals I have tried to show that there is little or no evidence in favor of such a view. In the case of plants I admit that under certain circumstances the presence or quantity of certain materials, especially food stuffs, may play a part in regenerative processes. But even in plants, despite the high authority by which the hypothesis is supported, I am sceptical whether formative stuffs are the chief factors in the result in those cases where polarity is involved. Let us examine the hypothesis more carefully. Bonnet suggested, in 1745, that the development of a head on one end of a piece of the worm, *Lumbriculus*, and of a tail on the other end of the piece, is due to fluids that flow forwards and backwards respectively, and act on head-germs at the anterior end of the piece, and on tail-germs at the posterior end. The accumulation of the head-stimulating fluid at the anterior end of the piece is supposed to awaken the germ of a head that lies at the anterior end. Conversely the tail-stimulating fluid, accumulating at the posterior end of the piece, awakens there the germs of the tail. It is unnecessary to point out that both the assumption of head- and tail-germs, and also the forward flow of certain kinds of substances, and the posterior flow of other kinds of substances are entirely fictitious assumptions, which from our modern point of view would be more difficult to account for than the phenomenon of regeneration itself.

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* Read by invitation before the Botanical Society of America, at Washington, December 31, 1902.

† Morgan, T. H. Regeneration, 88–90. 1901.

Sachs made use of the same idea, but in a very different form. He thought that the development of shoot-buds and of root-buds depended on the presence of certain substances in the plant. In order to account for the development of the shoots at or near the distal end of the piece, and of roots at the proximal end, he further postulated that the shoot-forming substances flow upwards, and the root-forming substances downwards — in response to the action of gravity. Vöchting's careful and elaborate series of experiments showed that the results cannot be explained so simply. He believes that an inner organization, or polarity, is the main factor in determining the result. Later Sachs also laid more emphasis than he had done at first on this innate factor.

Goebel appears at times to advocate strongly the idea that the flow of substances in the plant is the cause of several of the phenomena of regeneration. At other times he applies the hypothesis in such a vague way and under so many forms, that depend on quite different principles, not clearly kept apart, that the explanation often appears quite confused.

In his account of his experiments with seedling plants he makes little use of the hypothesis. On the other hand, in his beautiful experiments with cuttings of the stem of *Bryophyllum* he speaks out strongly in favor of the view that the results can be best explained on the assumption of the flow of certain substances, or at least of their accumulation in the plant. He thinks that the results of the experiments with the isolated leaves of the foliaceous liverworts can be best explained without assuming polarity, which in turn he here supposes to be associated with the absence of fibrovascular bundles in the leaves. He ignores the well-known fact that in many of the algae, which are extremely simple in structure, the polarity is as strongly expressed as in the regeneration of the higher plants. Moreover, the unicellular animals and plants show well-marked polarity. At other times Goebel speaks of certain growing regions — apical buds or cells — as drawing on the general supply of certain substances, and by continually exhausting these inhibiting the growth of other buds less advanced or less fortunately situated. He does not, I believe, sufficiently discriminate between this possibility, and the other view of the direction of the flow itself determining the development of certain parts.

I shall try to keep apart the idea that the presence of some particular substance may be the immediate cause of the growth of a part, and the idea of the flow of particular substances in a given direction as the immediate cause of growth. Moreover, it will be well to discriminate between the two possible causes of the flow. The polarity itself is sometimes hinted at by Goebel as the cause that determines the direction of the flow. On the other hand we may suppose that the flow is always towards the region where less of the substance exists and from the region where more is present.

The theory of mobile stuffs was first invented to explain the phenomenon that we call polarity. It is especially this part of the theory that I contest. I do not deny that the presence of certain substances in a piece may determine its reaction, neither do I question that a flow of certain substances in definite directions in the plant takes place, but I suspect the real cause of the flow in a given direction is dependent on the presence of certain organs, where the substances are being used or changed into other substances. Let us take a specific case and make definite applications of these different points of view. If a piece of the stem of a willow-plant is cut off and suspended in a moist atmosphere (its leaves having been previously removed) with its apical end upward, it will be found that the buds near the upper end of the piece begin first to grow, and grow more rapidly than those below them.

The buds near the base of the piece may not develop at all. The reverse is true in regard to the roots. They appear only at the base of the piece.

On Sachs' original assumption the development of the leaf-buds at the upper end of the piece is due to the accumulation at the upper end of some substance that causes them to develop. The development of the roots at the lower end is supposed also to be due to the presence there of another kind of substance. Vöchting showed that when the piece is turned upside down practically the same result follows; namely, the shoot-buds develop at the distal end of the piece, which is now the lower, and roots at the proximal end which is now the upper. This and other experiments make it highly probable that external factors play a very subordinate rôle in the development.

Now Goebel, following Sachs, is also at times inclined to ascribe the results of this, or of similar experiments, to the flow of different substances in the piece in different directions, but the cause of the flow is now ascribed to an internal factor, namely, to the polarization of the tissues themselves. It is somewhat ludicrous to find that while the hypothesis of formative stuffs was first invented to explain the polarity of the piece, the polarity is now assumed in order to account for the flow of the stuffs. My first question then is this: Is there any evidence to show that the polarity of the piece determines the direction of the flow of substances in the piece? I should also like to ask, is there any evidence to show that after the removal of a piece the flow of substances in it continues in the same direction as when the piece was a part of the plant?

In the first place can we account for the regeneration of pieces of the stem by means of the presence of formative stuffs, without assuming them to flow in definite directions? Let us see where such an assumption will lead. We may assume that when the piece is cut off certain substances accumulate in it. The excess of these substances tends to start the development of the leaf-buds and root-buds. Let us further assume that those leaf-buds will begin to develop that are the youngest, and these will always be those nearer the distal end. As they develop they will, by using up the substances present, retard the development of the other buds that are less developed. But in the case of the roots, the second assumption would have to be reversed, since those that develop are the oldest root-buds.

In this analysis I have attempted to give an explanation of the results without making use of the hypothesis of a directive flow of the formative stuffs, but it is clear that while the explanation may appear to hold for the shoots, it breaks down when applied to the roots; and, I believe, that whatever form the hypothesis takes it meets with inherent difficulties.

For example, let us take the application that Goebel has made in his attempt to explain the results of two different experiments with cuttings of begonia. He found that if his cuttings did not produce roots at the lower end of the stem, then the buds in the incisions of the leaves began to develop. He explains their development as due to the non-development of roots, and the consequent accumulation of some substance in the plant. But this will only account for the development of the roots of the plantlets on the leaves, and not for the leaves of the plantlets.

Conversely, he found by removing all the buds from a plant that the buds in the incisions of the leaf began to develop. This again he explains on the hypothesis that those substances that are generally used up by the growing points have accumulated, when these parts have been removed. This might appear to account for the development of the leaf-buds in the incisions of the leaves, but not for the rootlets. The hypothesis proves too much.*

My second question is this: May we not meet in these cases of regeneration with a phenomenon essentially similar to that which recent experimenters on the development of the non-fertilized animal egg have encountered? Contrary to the opinion first expressed, that the parthenogenetic development was due to the entrance of certain fertilizing ions into the egg, it has turned out that almost any kind of stimulus may start some eggs to develop. Such different kinds of things as salt-solutions, sugar, cold, heat, and even shaking will start the development of the egg of the star-fish. May this not be also the case with the piece of the plant? Will not any physical change affecting the germ start its development? But if this is the case the difference in the behavior of the distal and proximal buds still remains to be accounted for, and this is the main point now under discussion. If we should be tempted to supplement the first assumption by making use once more of the idea suggested above in another connection, namely, that the youngest buds will be the first to develop, we should still, as we have already seen, get into a difficulty in regard to the roots.

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* It is taken for granted here that the shoot- and root-forming substances are different.

I am of the opinion that the phenomenon of regeneration can not be explained by a purely chemical hypothesis. I suspect, at least, that certain physical conditions may be equally important. My meaning can be best illustrated by certain experiments that I have recently made with the tubularian hydroid, *Tubularia Mesembryanthemum.* This case is especially interesting in the present connection, because it is the only instance in modern times in which the hypothesis of formative stuffs has been applied to animals to explain regeneration. Moreover, hydroids react in many ways to external stimuli much like plants.

If long pieces of the stem of tubularia are cut off, and then the head or hydranth be removed from the distal end, it will be found that a new head develops in the course of twenty-four hours. This head appears at the distal end of the piece. After another twenty-four hours another head develops on the other, the proximal, end of the piece.

The stem as well as the hydranth-head of tubularia contains a red pigment. Before a new head develops at a cut end the same red pigment begins to appear in this region. Loeb suggested that this pigment is a formative stuff produced by the stem, and that its accumulation at the anterior end gives the stimulus for the formation of a new hydranth. Later Driesch also studied the regeneration of these pieces of tubularia, and observed that red pigment appears in great quantity in the fluid that circulates in the center of the piece. He thought that its presence might act quantitatively, and determine the kind of incomplete structures that short pieces of the stem often produce.

I have been able to prove that both of these suggestions are wrong, because in the first place the amount of pigment that develops in small pieces is much greater than that which was at first present. Second, the amount in the stem does not decrease, while that at the end is increasing; and third, the red pigment of the circulating fluid disappears, not by going into the forming wall of the new hydranth, but by being collected into a ball in its stomach. Stevens has shown that this ball is later vomited from the mouth. Thus the pigment hypothesis of tubularia has been disposed of. Let us now consider the experiments that bear directly on my main theme. I have just pointed out that two heads develop on pieces of the stem of tubularia, one twenty-four hours after the other. This delay in the appearance of the proximal head would be interpreted on the stuff-hypothesis as due to the distal head, that first develops, using all the available hydranth-forming material. It can be shown that this cannot be the explanation. First, if a thread is tied around the middle of the piece the development of the distal hydranth is not delayed, but the development of the proximal hydranth is greatly hastened. Second, if a piece is simply bent, the proximal head will develop almost as soon as the distal one. Third, short pieces (if not so small that the usual kind of development is interfered with) produce distal heads as soon as do longer pieces; thus showing that the amount of material in a long piece is more than ample to allow a hydranth to develop at each end at the same time. Fourth, if the two ends of a long piece are allowed to close, and if then the piece is cut in two, the development of the distal hydranth is hastened. We may conclude from these experiments that the delay in the appearance of the proximal hydranth is not due to the direction of the flow of the formative substances, because when a long piece is simply cut in two the development of the proximal hydranth may be hastened. The delay is due, only in a very small degree, to the polarity, because if the piece is simply tied in the middle the development of the proximal hydranth is hastened. Neither can the delay be due to the amount of food-stuff available, because pieces much shorter than half of these long pieces produce distal hydranths as soon as do the longer pieces. The stuff-hypothesis fails to explain the facts from every point of view.

The results certainly suggest that some physical factor enters into the problem. It seems to me that whatever this physical factor may be, it is the same that we find acting wherever growth and the formation of new structures are taking place.

In my book, "Regeneration," I offered, as a pure conjecture, the suggestion that this physical factor expresses itself in the form of different tensions in the living tissues. Goebel asks whether such a conception puts the question in any clearer light than before. I am inclined to think that the idea is not entirely worthless, and it should not be forgotten that I pointed out, as emphatically as possible, that the view is only conjectural and must be tested by further work. It was offered as a possible working hypothesis, and it is unfair to treat the suggestion in any other light. If the view appears too vague it can be given a more practical form by assuming that the differences in tensions are simply the outcome or expression of osmotic changes, which are themselves in turn the result of the presence of certain chemical substances present, or being produced in the organism.*

BRYN MAWR COLLEGE.

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* Since the above was written Matthews has suggested that my tension-hypothesis may be an expression of the electrical conditions in the piece; in short, that "polarity" is an electrical phenomenon; possibly, I may add, due to the movement of ions.

The Genus Riella, with Descriptions of new Species from North America and the Canary Islands*

By M. A. Howe and L. M. Underwood

(With Plates 11 and 12)

The genus *Riella* occupies a unique position among the Hepaticae. The striking peculiarities of its gametophytic phase have attracted the attention of such morphologists as Hofmeister, Leitgeb, and Goebel, in addition to the interest excited among those who have devoted themselves more exclusively to a study of the systematic relations of the Hepaticae. *Riella helicophylla*, an Algerian species, is alluded to in some of the standard botanical text-books as being peculiar among the liverworts in having a leaf-like lamina or wing disposed spirally in relation to the axis or stem. Later studies of this species, however,† indicate that the supposed helicoid spiral arrangement was exaggerated in the original figures and description and that the spiral appearance is due to the slight torsion of a stem bearing a strongly undulate lamina. Nevertheless, the species of *Riella* in general are peculiar enough in that the lamina or wing appears at first sight to be attached to one side of the stem; but the position of the sexual organs, of the root-hairs and of the scale-like appendages shows that the plant is bilaterally symmetrical in the plane of the wing and the conviction is now general that the wing is dorsal in relation to the stem. Goebel‡ has expressed the opinion that the chief difference between *Riella* and the other liverworts is that in *Riella* the development of the thallus is in the vertical instead of in the horizontal plane. The species of *Riella* are all aquatic, commonly growing entirely submerged, and it is doubtless this condition of growth which makes possible the leading peculiarity in form.

The growing point of a young plant or of a young branch of

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* Read in abstract before the Botanical Society of America, Ninth Annual Meeting, Washington, D. C., December 31, 1902.

† Trabut, Rev. Gén. Bot. 3: 451. 1891. Stephani, Bull. Herb. Boiss. 7: 659. 1899.

‡ Flora, 77: 107. 1893.

Riella is not apical in the ordinary sense of the word, but intercalary. The whole tissue of the young shoot appears to be meristematic at first and of one layer of cells. Later, the growth activities are concentrated at either one or two points on the margin of the shoot intermediate between its distal and proximal extremities. If at *two* points, these are situated on opposite margins of the shoot. The new cells formed on the upper or distal side of the growing point now contribute to the growth of the unistratose wing, which is dorsal in position. The new cells formed on the lower or proximal side of the growing point go to constitute the multistratose stem, which is ventral in position. If two growing points on opposite margins of a young shoot persist, a double or twin plant is formed, the two branches of the axis bearing a single continuous dorsal wing. If, however, only one growing point persists, the plant or branch is apparently one-sided, with stem on one side and wing on the other, though in reality the wing is dorsal and the stem ventral.

On account of the absence of elaters, *Riella* was at first placed with the Ricciaceae, together with *Sphaerocarpus*, in which, likewise, elaters are not developed. A better understanding of the morphology of these two genera has led to placing them in the order Jungermanniales, of which, together with the exclusively American genus *Thallocarpus*, they constitute the simplest members. The genus *Riella* forms the subfamily Rielloideae and in the usual arrangement stands between the Sphaerocarpoideae and Metzgerioideae in the family Metzgeriaceae (the Jungermanniaceae anakrogynae of Leitgeb and Schiffner).

The geographical distribution of this strongly characterized genus *Riella* is of interest. Up to within a few months ago, the genus was supposed, as far as the literature on the subject is concerned, to be confined to the Mediterranean drainage basin of Africa and Europe, with seven species, as commonly recognized. One of these, however, *Riella Gallica*, was reduced by M. Corbière in the last number of the Revue Bryologique for 1902 to forma *Gallica* of the Algerian *R. Battandieri*. To these seven known species, or six, as now conceived, another from a region far removed was added by Morten P. Porsild in a recent number of the Botanisk Tidsskrift, where *R. Paulsenii* from Turkestan was described and figured. References to the principal literature dealing with the genus, together with the names and distribution of the species hitherto described, are given below:

RIELLA Mont. Ann. Sci. Nat. III. **18**: 11. 1852. Leitgeb, Untersuch. Leberm. **4**: 74–87. *pl. 7, 8. f. 1–8.* 1879. Trabut, Rev. Gén. Bot. **3**: 449. 1891. Goebel, Flora, **77**: 104–108. *pl. 2. f. 1–3.* 1893. Schiffn.; E. & P. Nat. Pflanzenfam. 1^3: 51. 1893. Stephani, Bull. Herb. Boiss. **7**: 658. 1899.

Duriaea Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1115. 1843; Ann. Sci. Nat. III. **1**: 228. 1844. G. L. & N. Syn. Hep. 593. 1846. Not *Durieua* Mérat, Mém. Soc. Roy. Sci. Lille, **1827–28**: 432. 1829. Not *Durieua* Boiss. & Reut. Diag. Pl. Nov. Hisp. 14. 1842.

Maisonneuvea Trevis.* Mem. R. Ist. Lomb. III. **4**: 442. 1877.

Duriella Clauson & Billot, *fide* Schiffn., *l. c.*

RIELLA BATTANDIERI Trab. Rev. Bryol. **13**: 35. *pl. 3.* 1886. Schiffn. Bot. Centralb. **27**: 240. *pl. 1. f. 5.* 1886.

ALGERIA: Maison-Blanche near Algiers, *Battandier, Trabut.*

EXSICC.: Husnot, Hep. Gall. no. 173.

Forma GALLICA (Bal.) Corbière, Rev. Bryol. **29**: 113. 1902.

Riella Gallica Bal.; Trab. Rev. Gén. Bot. **3**: 450. *pl. 18. f. G.* 1891.

FRANCE: Roquehaute, near Béziers, Hérault, *Balansa*, 1866, *Crozals*, 1902; mare de Rigaud near Agde, Hérault, *Crozals*, 1902.

RIELLA COSSONIANA Trab.; Batt. & Trab. Atlas Fl. Alg. **1**: 6. *pl. 2. f. 1–8.* 1886; Rev. Bryol. **14**: 12. *pl.* 1887.

ALGERIA†: El Kreider, Province Oran, *Cosson*, 1854; *Trabut*, 1885.

EXSICC.: Husnot, Hep. Gall. no. 174.

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* Trevisan rejected *Riella* Mont. on account of *Riella* Raf.; Lév.; Orb. Dict. Univ. Hist. Nat. **8**: 488. 1849. This, however, is a *nomen nudum* and is probably a misprint for *Rimella* Raf. Jour. Phys. **89**: 106. 1819.

† Allusions to the occurrence of *Riella Cossoniana* in the Canaries have recently appeared in print (Bot. Tidsskrift, **24**: 327. 1902; Rev. Bryol. **29**: 110. 1902), but it is possible that these refer to *Riella affinis*, described below as new.

RIELLA HELICOPHYLLA (Bory & Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Duriaea helicophylla Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: *229.* 1844. G. L. & N. Syn. Hep. 593. 1846. Mont.; Bory & Durieu, Expl. Sci., Algérie, Bot. *pl. 34.* 1846–49.

ALGERIA: Province Oran, *Durieu, Trabut.*

EXSICC.: Husnot, Hep. Gall. no. 172.

RIELLA NOTARISII (Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Sphaerocarpus Notarisii Mont.; De Not. Mem. R. Accad. Torino, II. **1**: 343. *f. d. 1–8.* 1839.

Duriaea Notarisii Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: *229.* 1844. G. L. & N. Syn. Hep. 593. 1846.

SARDINIA: near Pula, *De Notaris,* 1834.

GREECE: Phalerus, *Chaboisseau, fide* Stephani.

RIELLA PARISII Gottsche; G. & R. Hep. Eur. no. 375. 1867. [Illust.] Leitgeb, Untersuch. Hep. **4**: 76. *pl. 7. f. 17.* 1879. Stephani, Bull. Herb. Boiss. **7**: 661. 1899.

Riella Clausoni[*s*] Letourneux; Husnot, Hepaticologia Gallica, 87. *pl. 12. f. 151.* 1881. Batt. & Trab. Atlas Fl. Alg. **1**: 13. *pl. 8.* 1886. Trab. Rev. Gén. Bot. **3**: 452. 1891.

ALGERIA: Maison-Carrée, etc., near Algiers, *Clauson, Paris, Trabut.*

EXSICC.: G. & R. Hep. Eur. no. 375; Husnot, Hep. Gall. no. 121.

RIELLA PAULSENII Porsild, Bot. Tidsskrift, **24**: 323–327. *f. 1–3.* 1902.

TURKESTAN: Bokhara, *Paulsen,* 1898.

RIELLA REUTERI Mont. Ann. Sci. Nat. III. **18**: 12. 1852. Hofmeister, Bericht. Verh. Kgl. Sächs. Gesellsch. Wiss. 1854: 92–95. *pl. 4.*

SWITZERLAND: near Geneva, *Reuter,* 1851.

In describing *Riella Paulsenii*, the first species of the genus known to occur outside of the Mediterranean region, Porsild expresses the surmise that the distribution of the genus may prove to be still more widely extended, which is well verified by the known existence at the present time of three specimens of *Riella* collected within the boundaries of the United States. One of these, strangely enough, was collected by Schott as long ago as 1855, but has remained unstudied and unnoted in literature. In April, 1902, western Texas, the region from which Schott's specimens came, was visited by Professors F. S. Earle and S. M. Tracy, who secured further specimens which we consider the type of the well-marked species described below:

Riella Americana sp. nov.

Erect or ascending, 10–30 mm. high, simple or more commonly 1–4 times furcate: axis elliptical in section, 0.2–0.8 mm. wide, mostly 6–10 cells thick, root-hairs borne only on the basal parts and usually few: wing 2–5 mm. broad, rounded-falciform at apex, slightly undulate-crisped, subentire or erose, tapering toward the base and commonly deficient below the first dichotomy; cells near the axis about 60 μ in greatest diameter, those near the margin about 40 μ: scales few, small, 0.2–0.6 mm. long, linguiform and obtuse or irregularly lanceolate and subacute, those near the growing apex usually intermingled with multicellular gemmae: gemmae trichomic in origin, soon oblong or orbicular-oblong in outline, showing later a median constriction and becoming finally panduriform and subspatulate: dioicous: antheridia about 0.36 × 0.16 mm., sometimes as many as 75 (including empty loculi) in a single elongated marginal series: ♀ gametophyte, or each of its branches, maturing for the most part 3–12 sporogonia in acropetal order: involucres smooth, ellipsoidal-ovoid or at full maturity subglobose-ovoid, 1.4–1.8 mm. × 0.8–1.2 mm., narrowed rather gradually to the truncate or slightly pointed subpapillose orifice: capsule globose, 0.8–1 mm. in diameter, seta about 0.2 mm. long, mostly a trifle shorter than the ovoid-conic foot: spores dark-brown, 100–130 μ in maximum diameter (spines included); outer face bearing numerous sometimes curved spines 10–24 μ long, with dilated apices, these spines more or less connected by radiating basal membranes forming irregular reticulations; inner faces bearing conical, non-capitate spines, 3–6 μ long, with basal membranes obsolescent or entirely wanting. (*Pl. 11; pl. 12, f. 21, 22*).

Limpia Cañon, Texas, F. S. Earle and S. M. Tracy, April 25, 1902, no. 251; this, the type specimen, is deposited in the herbarium of the New York Botanical Garden. The plants are said by Professor Earle to have been found in a pool headed by a small waterfall, forming mats on rocks and stones which were covered by 10–60 cm. of water in the dry season. The same species was collected by Schott in 1855, his specimen originating from "Limpia, near its head, Western Texas." His plants, though otherwise agreeing perfectly with those of the more recent collection, are considerably smaller and are mostly unbranched. A *Riella* (in herb. A. W. Evans) was collected by Mr. De Alton Saunders at Brookings, South Dakota, in 1898. The material is scanty and the sporogonia are so immature that the spore-characters cannot be determined. The involucres and scales are similar to those of *R. Americana* and it is quite probable that the species is the same. This South Dakota specimen marks the northern limit in the known distribution of the genus.

Riella Americana is easily distinguished from any of the species hitherto known. Its nearest ally is probably *Riella Battandieri* f. *Gallica*, of southern France, which differs in being monoicous,* in the narrower wing, the smaller spores, with shorter non-capitate spines, etc. Gemmae have not before, to our knowledge, been definitely described in any species of *Riella*, though Goebel (Flora, **77**: 105. 1893) in figuring three young stages of *Riella Battandieri* (?) remarks in a footnote that one of them sprang from a "Zellkörper" while the others came from "Zellfäden." By analogy with what we have observed in *Riella Americana*, it seems very probable that his plant from the "Zellkörper" came from a brood-body of some kind, while those from the "Zellfäden" were derived from spores. The young plants of *Riella Cossoniana*, represented by Trabut in his figures 1 and 2 (*l. c.*), also, with little doubt, originated from gemmae. The gemmiform appendages figured by Trabut on the axis of his *R. Gallica* are of a more doubtful nature. These were not found by Corbière in his recent studies of what he believes to be the same species; possibly they were designed to represent remains of old involucres and sporogonia.

The gemmae of *R. Americana* originate on the axis as trichomic outgrowths, each of about three cells in a single series (*f. 10, 11*) of which the terminal cell is usually the largest. The two

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*Corbière, Rev. Bryol. **29**: 111, 113. 1902.

lower cells then divide in the sagittal plane (*f. 11*) and this this is followed by a division of the terminal cell. The basal cells afterward grow out and divide in such a way as to give the body a free margin throughout its periphery, though it remains attached to the axis for a considerable time by a single cell on its proximal surface. *F. 13–16* show stages in the subsequent development, *14* being a view of its proximal surface, and *13*, *15* and *16* of its distal, the point of attachment in each case being at *b*. The part which is derived from the base of the original trichome consists soon of cells which are smaller, richer in protoplasm, and capable of more rapid division than those of the part which is derived from the apex of the original trichome. This part of basal origin is more regularly suborbicular in outline than the other. In neither part can an apical cell be pointed out with any certainty. In the earlier stages the whole body seems to be meristematic; later a constriction appears near its middle and the formation of new cells is then the most active in the zone of this constriction. The larger-celled part, derived from the apex or distal end of the initial trichome, becomes at about this time more than one cell thick in its middle and terminal regions and shows papilliform outgrowths, the beginnings of the root-hairs. The smaller-celled portion derived from the base or proximal end of the initial trichome remains only one cell thick except in the isthmus of constriction where it finally, in part at least, becomes two or more cells thick. *F. 16* shows a well-developed gemma inverted as regards its original relations to the axis of the gametophyte. The edges of the two parts here overlap slightly in the zone of constriction. Later, the isthmus elongates, giving the body a somewhat panduriform or at length subspatulate outline. *F. 17* shows the outline of a gemma in an older stage, and *f. 18* a still later development.

Attempts to germinate the spores of the plants collected by Earle and Tracy were made in the autumn and winter of 1902–03. Though the spores were to all appearances mature, the attempts were successful in the case of only a very few spores, which were carried a little beyond the stage represented in our *f. 21* and *f. 22*. The germ-tubes in every case observed came out from near the middle of the outer or more spiny face. This tube is first divided by transverse walls into a single row of several cells, three or four of the terminal of which are then divided by median longitudinal walls. This divided terminal portion by growth and multiplication of its cells becomes ovate or spatulate in outline. In the latest stage that we have been able to see, one somewhat more advanced than that represented in our *f. 21*, the whole body still consists of only one layer of cells. *F. 22* shows in edgewise view the same plant that is shown in *f. 21*. A root-hair is sent out from the spore soon after the emergence of the germ-tubes.

A second species of *Riella*, apparently new, from the Canary Islands, has come to our attention; this we would describe as follows:

Riella affinis sp. nov.

Apparently erect or ascending, becoming prostrate on the subsidence of the water, 6–15 mm. high, densely caespitose, simple or sparingly furcate: axis flattened, 0.1–0.4 mm. wide, mostly thin and flaccid, radicelliferous at base: wing 1–3 mm. broad, rounded or obtusely pointed at apex and falciform, deeply lobed; cells near the axis 45–60 μ in diameter, those near the margin about 30 μ: scales usually inconspicuous, 0.2–0.5 mm. long, linguiform, lanceolate, or linear, obtuse or acute: monoicous: antheridia solitary or in groups of 2–7 in more or less profound marginal sinuses: sporogonia mostly 3–10: involucres ovoid, 8-winged, 1.4–2 mm. long, 1–1.5 mm. wide (incl. wings), much contracted and often subacute at mouth; wings 0.1–0.2 mm. broad, with undulate-sinuate or subentire margin: capsule subglobose, 0.8–1 mm. in diameter, seta 0.1–0.2 mm. long: spores brown, 85–120 μ in maximum diameter (spines included); outer face densely covered with spines 6–15 μ long, their apices mostly truncate, often slightly dilated, occasionally emarginate-bifid, rarely acute, the supporting basal membranes sometimes almost deficient but commonly forming a few imperfect areolae; inner faces with mostly truncate or obtuse spines or warts 3–6 μ high, basal membranes wanting. (*Pl. 12. f. 23–36.*)

On the bank of a reservoir, Tafira, Grand Canary, June, 1897, O. F. Cook (no. 729). We are informed by the collector that the specimens were found partly submerged and partly exposed on a sloping bank.

Riella affinis is allied to the Algerian *R. Cossoniana* Trabut and the central Asian *R. Paulsenii* Porsild, but differs from both in being monoicous and in the much longer spines of the larger spores. The involucres are less globose and more pointed at the apex than those of *R. Cossoniana.* Judging from two specimens of *R. Cossoniana* collected by Professor Trabut, *R. affinis* has the appearance of being a larger species with broader lamina, though this might not appear from a comparison of the measurements given above with those given by authors for *R. Cossoniana.* Our specimens of *R. affinis* are prostrate and more or less entangled with mud and are so delicate and fragile that it is quite possible that the measurements in the above description may fail to do full justice to the height of the plant. It may be remarked that in occasional capsules the spores though showing a well-developed brown coloration have short spines or papillae much like those of *R. Cossoniana;* such spores are always smaller than is normal for the species and are probably immature or else have ripened under abnormal conditions.

Our experiments in germinating the spores of *Riella affinis* have been more successful than those with the spores of *Riella Americana*, though they were not begun until December, 1902, five and a half years from the date of collection of the specimens. More than half of the spores experimented with germinated in a few days by being placed on a piece of wet filter-paper in a glass dish kept in a moist chamber at ordinary living-room temperatures. The germ-tube in practically all cases emerges, as in *R. Americana*, from the outer or more spiny face of the spore, usually near its middle. The root-hair follows a little later, its lumen remaining continuous with that of the germ-tube. The length of the germ-tube varies exceedingly. Finally, there appears in it a somewhat curved transverse wall with its convexity turned toward the spore. The part above contains most of the starch grains and in the course of time begins to show chlorophyll, cell-divisions meanwhile taking place as described above for *R. Americana.* The length of the germ-tube from the spore-wall to the curved septum has been observed to vary in different cases from 0.02–0.7 mm. One or two root-hairs, in addition to the one which comes from the base of the germ-tube, may spring out later from some part of the filamentous stalk of the young gametophyte. The forms assumed by the young gametophytes are extremely varied and are doubtless determined to a considerable extent by the conditions of illumination, though no exact investigations were undertaken to demonstrate the influence of light in this matter. The prevailing form, however, while still unistratose, is spatulate, though flabelliform and linear outlines are not uncommon and grotesquely lobed and branched stages are often met with. Linear or ribbon-shaped forms, like that shown in *f. 36*, are especially common when the young plants are from the first well covered with water. Just below the chief growing point *c*, in the stage illustrated by *f. 34*, there are cell divisions in the plane of the paper, which possibly foreshadow the axis or stem, though they may have arisen in this case through changed relations to the light. We have not yet been able to follow the development much beyond this point, but we have grounds for believing that the subsequent history is essentially as described by Goebel (*l. c.*) for young plants of *A. Battandieri* with the exception that the wing is probably more lobed than in that species. In most cases, the development is confined to practically a single plane, though occasionally, as in the case represented by *f. 35*, the wing-lobes show an irregularly spiral arrangement, due perhaps to changed positions in regard to the light.

Explanation of Plates

[The drawings have been prepared by M. A. Howe, chiefly with the aid of a camera lucida.]

PLATE 11. *Riella Americana* Howe & Underw.

1 and 4. ♂ gametophytes, natural size.

2 and 3. ♀ gametophytes, natural size.

5. Terminal portion of a branch of the ♂ gametophyte, with a young branch at the apex, × 11.

6. Terminal portion of a branch of the ♀ gametophyte, × 11.

7. An involucre, with mature sporogonium, × 16.

8. A scale, × 55.

9. Portion of axis near the apex, showing gemmae and scales, × 40. The gemmae are shown at *a* and below; the scales are, in this case, nearer the wing.

10–18. Stages in the development of the gemmae. See text, pp. 219 and 220.

10. A trichome destined to become a gemma, in distal (outer) aspect, × 193.

11. A similar stage in lateral view, × 193.

12–15. Later stages; 12, 13, and 15 in distal aspect, 14 in proximal, × 193; *b*, point of attachment.

16. A more advanced stage inverted as regards its original relations to the axis and as regards the preceding figures, × 193.

17. Outline of a gemma in a later stage, × 55.

18. A young gametophyte derived from a gemma, × 28.

19 and 20. Spores, outer and inner faces, × 305.

Figures 4, 18–20, are drawn from material collected by Schott in 1855; the others from material collected by Earle and Tracy, April, 1902.

PLATE 12

Figs. 21 and 22, *Riella Americana* Howe & Underw.; Figs. 23–36, *Riella affini* Howe & Underw.

21. Germ plant, × 245.

22. Same in edgewise view, × 245.

23. Gametophyte of *Riella affinis*, × 11.

24. Apical portion of another, with involucres and antheridial loculi, × 11.

25 and 26. Involucres, × 16.

27 and 28. Spores, outer and inner faces, respectively, × 330.

29 and 30. Germinating spores, × 55.

31. Germ plant, showing the earlier cell divisions, × 245.

32–36. Various forms assumed by the germ plants, × 55. The principal vegetative point is indicated by *c*. The elongate form represented in Fig. 36 is common when the young plants are well covered with water.

The Polyporaceae of North America.—III. The Genus Fomes

By William Alphonso Murrill

The generic name *Fomes* is usually accredited to Fries, but this author never employed it to designate a genus. In Novae Symbolae, 46, 1851, the genus *Polyporus* is subdivided into *Eupolyporus* and *Fomes*, the latter division being described as follows:

> "Pileus primitus lignoso-induratus (raro molles, plorantes), contextu floccoso intertexto, crusta rigida obductus, azonus, sed demum concentrice sulcatus. *Fungi perennes (vulgo stratose), reviviscentes, sed stratum annuum vegetum tantum est.*"

In listing species Fries wrote the word *Fomes* in parenthesis after *Polyporus.*

Gillet (Champ. France, **1**: 682. 1878) raised *Fomes* to generic rank and described the group as follows:

> "Hyménium poreux; pores non séparables entr'eux, distincts du chapeau, disposés par couches stratifiées. Espèces ligneuses-subéreuses, stipitées, dimidiées ou résupinées, recouvertes d'une croûte dure, épaisse et st. marquée de zônes annuelles séparées par des sillons concentriques. Champignons vivaces à accroissement indéfini."

Under this genus Gillet lists thirteen species, the first being *F. marginatus*, which is therefore considered its type. Most of the remaining species of *Fomes*, as the term is used in Saccardo's Sylloge, were assigned to this category by Cooke in Grevillea (v. 13 and 14, 1884–85). Karsten was the first to divide generically this large group of perennials, which now comprises a half dozen or more genera, the name *Fomes* being connected with the natural subdivision to which *F. marginatus* belongs. Karsten's name *Fomitopsis*, applied to this subdivision in 1881, unfortunately becomes a synonym of *Fomes.* His names *Ganoderma* and *Elfvingia*, however, hold for other important subdivisions.

Synopsis of the North American Species

1. Context white or yellowish. 2.
   Context flesh-colored, pileus often effused or effused-reflexed, flesh-colored, soon blackening, tubes round, 3–4 to a mm. 1. *F. roseus.*

2. Pileus over 3 cm. broad. 3.
   Pileus less than 3 cm. broad. 8.

3. Pileus encrusted, surface darker than the context. 4.
   Pileus rarely encrusted, surface concolorous with the context. 9.

4. Pileus thick, sulcate, ungulate, rarely applanate. 5.
Pileus at first thin, triangular or lobed, shining reddish-chestnut above, becoming dimidiate, ungulate at the center, and dull brown: spores ovoid, 3.5 × 5 μ. Pileus attached by a lateral stipe which soon disappears. 7. *F. stipitatus.*
Pileus thin, distinctly zonate, irregular or applanate, crust brown to black: spores ovoid, hyaline, 6 × 4 μ. 2. *F. annosus.*
5. Surface not soon rimose, older pores not visible. 6.
Surface soon becoming rimose, deeply sulcate, older pores visible in the upper projecting annual layers: pileus exactly ungulate, found only on *Shepherdia*. 4. *F. Ellisianus.*
6. Pores 4–5 to a mm. 7.
Pores 2–3 to a mm.: pileus subtriangular, gray to black, context white to pale cinnamon: spores ellipsoidal, 7–8 × 6–7 μ; abundant on *Fraxinus*. 5. *F. fraxinophilus.*
7. Pileus applanate, many times sulcate, horny encrusted, extremely hard in substance; tropical. 6. *F. ligneus.*
Pileus ungulate, applanate when very large, deeply annually sulcate, surface often resinous, bay or black in color; abundant on coniferous trees in temperate regions. 3. *F. ungulatus.*
8. Pileus ungulate, becoming black only at the base, zonate and concentrically sulcate in age, tubes over 0.2 cm. long. 8. *F. Ohiensis.*
Pileus scutellate, uniformly black when quite young, tubes less than 0.2 cm. long, context thinner than tube-layer. 9. *F. scutellatus.*
9. Pileus cylindrical, tubes long, visible at edges of older strata, context friable, becoming bitter; growing on conifers. 10. *F. Laricis.*
Not as above. 10.
10. Pores large, 2 to a mm., becoming reddish when bruised, annual strata separated by thick layers of context; tropical. 13. *F. rubritinctus.*
Pores small, 5–7 to a mm., not changing to reddish when bruised. 11.
11. Tubes less than 2 mm. long each season, context punky, hymenium glistening, not becoming dark in color. 11. *F. populinus.*
Tubes more than 2 mm. long each season, context hard and rather friable, hymenium becoming smoky or brownish, cracking in age. 12. *F. Meliae.*

1. FOMES ROSEUS (Alb. & Schw.) Cooke

Boletus roseus Alb. & Schw. Consp. Fung. 251. 1805.

Polyporus roseus Fr. Syst. **1**: 372. 1821.

Polyporus carneus Nees, Nov. Act. Nat. Curios. **13**: *pl. 3.* 1827.

Fomitopsis rosea Karst. Rev. Myc. **3**: 18. 1881.

Fomes roseus Cooke, Grevillea, **14**: 19. 1885.

Fomes carneus Cooke, Grevillea, **14**: 21. 1885.

This fungus is very widely distributed and does serious injury to various coniferous trees both in Europe and America. Its form varies greatly with the character of the host plant. Besides the names mentioned above, *P. rufo-pallidus* Trog (Flora, **15**: 556.

1832. Fries, Icon. *pl. 186. f. 1*) doubtless refers to the same plant and I have a suspicion that *Polystictus arcticus* Fr. is also a synonym, since plants at Kew collected near Carlton in May, 1858, are only grayish zonate forms of *F. roseus.* The actual types of *P. arcticus* I have not seen.

A few of the collections examined are here listed: Finland (Karsten), Canada (Macoun, Dearness), Maine (Miss White), Newfoundland (Waghorne?), New Hampshire (Minns, Underwood), Ohio (James), New Jersey (Ellis), Colorado (Bethel, Pammell), West Virginia (Nuttall), Washington (Piper), Florida (Calkins), Nebraska (Kennedy), South Carolina (Ravenel), Alabama (Peters), California (McClatchie), Connecticut (Underwood), Georgia (Underwood).

2. FOMES ANNOSUS (Fr.) Cooke

Polyporus annosus Fr. Syst. **1**: 373. 1821. Icon. *pl. 186. f. 2.*

Polyporus serpentarius Pers. Myc. Eur. **2**: 82. 1825.

Polyporus subpileatus Weinm. Fl. Ross. 332. 1836.

Polyporus resinosus Rostk.; Sturm, Deutsch. Fl. **4**: 61–62. *pl. 29.* 1838.

Trametes radiciperda R. Hartig, Wicht. Krankh. Waldb. 62. 1874.

Fomitopsis annosa Karst. Rev. Myc. **3**: 18. 1881.

Fomes annosus Cooke, Grevillea, **14**: 20. 1885.

Heterobasidion annosum Bref. Untersuch. **8**: 154. *pl. 9.* 1889.

Polyporus irregularis Underw. Bull. Torrey Club, **24**: 85. 1897.

Kreiger 121, Romell 13, Sydow 3107, 1108, 504, Allescher & Schnabl 137, 432, Roumeguère 3111, 7248, Rabenhorst 405, de Thümen 106, Kunze 1, Briosi 2, Cavara 324. Sweden (Murrill), Tyrol (Bresadola), California (Harkness), Oregon (McBride), West Virginia (Nuttall), Pennsylvania (Gentry), Alabama (Earle, Baker, Woodward), Florida (Gory).

Many other specimens have been examined, but the abovementioned are sufficient to show that the plant is of wide distribution. It is particularly injurious to various species of coniferous trees.

3. FOMES UNGULATUS (Schaeff.) Sacc.

Boletus igniarius Scop. Fl. Carn. ed. 2. **2**: 469. 1772. Not *B. igniarius* L. 1753.

Boletus ungulatus Schaeff. Fung. Bav. **4**: 88. *pl. 137, 138.* 1774.

Boletus fulvus Schaeff. Fung. Bav. **4**: 89. *pl. 262.* 1774.

Boletus semiovatus Schaeff. Fung. Bav. **4**: 92. *pl. 270.* 1774.

Boletus marginatus Pers. Obs. **2**: 6–7. 1799.

Boletus pinicola Sw. Vet. Akad. Handl. 88. 1810.

Polyporus marginatus Fr. Syst. **1**: 372. 1821.

Polyporus pinicola Fr. Syst. **1**: 372. 1821.

Fomes marginatus Gill. Champ. Fr. **1**: 683. 1878.

Fomitopsis pinicola Karst. Rev. Myc. **3**: 18. 1881.

Fomes pinicola Cooke, Grevillea, **14**: 17. 1885.

Fomes ungulatus Sacc. Sylloge, **6**: 167. 1888.

A large and widespread species growing abundantly on coniferous trees, such as the hemlock and pine, and found more rarely upon deciduous trees standing near its usual hosts. Beech, elm, maple and birch are known to have been attacked by it in American and European forests where conifers abound. Fresh specimens collected on fir trees in Sweden correspond in all respects with Schaeffer's *B. ungulatus*, so I do not hesitate to use his name. Collections showing the range of this plant are as follows: Saxony (Krieger 13), Sweden (Romell 116, Murrill), Siberia (de Thümen 1906), France (Roumeguère 2205), Bohemia (de Thümen 814), Hungary (Linhart 250, 446), Canada (Macoun), New Hampshire (Minns), New York (Atkinson, Underwood, Murrill), Colorado (Crandall, Cockerell), West Virginia (Nuttall), Michigan (Wood), Maine (Ricker), Virginia (Murrill).

4. FOMES ELLISIANUS Anders.

Fomes Ellisianus Anderson, Bot. Gaz. **16**: 113. *pl. 12.* 1891.

Fomes circumstans Morgan, Jour. Cincinnati Soc. Nat. Hist. **18**: 37. *pl. 1. f. 4.* 1895.

This species was described from plants collected by Anderson in Montana during the summer of 1889. Its only host thus far reported is *Shepherdia argentea* Nutt., on the living trunks and branches of which it is very abundant in the Teton Valley.

Morgan's description is based on a collection in Dakota by T. A. Williams from the same host. His name refers to the half-encircling habit of the plant when it grows upon a branch. The fungus has also been collected in Colorado.

5. FOMES FRAXINOPHILUS (Peck) Sacc.

Polyporus fraxinophilus Peck, N. Y. State Mus. Rept. **35**: 136. 1882.

Fomes fraxinophilus Sacc. Sylloge, **6**: 172. 1888.

Ohio (Morgan, Gentry), Kentucky (Kellerman, Price), Missouri (Demetrio), Kansas (Bartholomew), Nebraska (Bates), Pennsylvania (Martindale), Iowa (McBride), Indiana (Underwood), New York (Peck).

This species is confined to the ash, on which it is very common. It has been confused with *P. fraxineus* (Bull.) Fr. by Cooke and some other mycologists. Anderson's no. 537 in the Parasitic Fungi of Montana was distributed under the name of *P. fraxinophilus* before it was described as *Fomes Ellisianus.*

6. FOMES LIGNEUS (Berk.) Cooke

Polyporus ligneus Berk. Ann. Nat. Hist. **3**: 387. 1839.

Fomes ligneus Cooke, Grevillea, **13**: 119. 1884.

Excellent specimens were collected in Nicaragua by C. L. Smith and in St. Kitts by Britton and Cowell. Plants from Mauritius at Kew bearing this name are specifically distinct from our fungus. *Fomes sulcatus* Cooke from Demarara is nearly allied to *F. ligneus.*

7. **Fomes stipitatus** sp. nov.

A plant of medium size with short evanescent lateral stipe, shining reddish-chestnut crust and broad white thin margin. Pileus exceedingly hard and horny, flat and triangular or somewhat circular when young, becoming dimidiate with ungulate center and thin spreading margin, which is usually lobed and often deeply cleft; hymenium normally plane, but frequently convex because of the upturned margin, 5 × 10 × 3 cm.; surface glabrous, varnished, reddish-chestnut, with numerous shallow concentric furrows, becoming shining black and at length dull smoky-brown; margin broad, flat, glabrous, obtuse, 3 mm. thick, crenate to cleft, sterile portion 0.5 cm. wide, white: context hard, woody, 0.5–1 cm. thick, pale ochraceous, with strands of dark-brown shining horny substance extending from the stipe to the margin in a tree-like fashion: tubes plainly though unevenly stratified, 2–4 mm. long each season, 4–5 to a mm., grayish-brown within, mouths circular, white or very pale yellow, dissepiments thick, obtuse, entire: spores broadly ovoid with attenuate base, light yellowish-brown, smooth, 3.5 × 5 μ: stipe lateral, 1 × 1 cm., cylindrical, equal, glabrous, shining black to dull brown, with substance like the context, apparently absorbed or overgrown as the pileus enlarges.

This very distinct and easily recognized species was collected by C. L. Smith and B. Shimek in Nicaragua during the winter of 1891–92. Its conspicuous varnished surface and lateral stipe suggest at once the genus *Ganoderma*, but more important characters connect it with *Fomes* and I have with some hesitation assigned it to this genus, recalling the fact that *Fomes ungulatus* often has considerable varnish on its surface and that an umbo often has its beginning in a reduced stipe.

8. **Fomes Ohiensis** (Berk.)

Trametes Ohiensis Berk. Grevillea, **1**: 66. 1872.

This plant is unusually small for the genus *Fomes*, making with *F. scutellatus* a rather distinct subgroup. It grows upon rails and dead branches of various deciduous trees. Among collections examined are those from Canada (Dearness), Kansas (Cragin), Michigan (Dennen), Ohio (James), New York (Peck).

9. FOMES SCUTELLATUS (Schw.) Cooke

Polyporus scutellatus Schw. Trans. Am. Phil. Soc. **4**: 157. 1832.

Fomes scutellatus Cooke, Grevillea, **14**: 19. 1885.

This minute species was described by Schweinitz from material collected on *Syringa* in Pennsylvania. It has since been found on alder, witch hazel, sweet gum and other deciduous shrubs and trees. Some of the collections examined are as follows: Pennsylvania (Everhart), Florida (Calkins), Maine (Harvey, Blake), Canada (Macoun), Delaware (Commons), Ohio (James), Alabama (Mell).

10. **Fomes Laricis** (Jacq.)

Boletus Laricis Jacq. Miscel. **1**: 164–203. *pl. 20–21.* 1778. Bull. Herb. France, *pl. 296.* 1786.

B. officinalis Villars, Delph. 1041. 1786.

B. purgans Pers. Syn. 531. 1801.

Polyporus officinalis Fr. Syst. **1**: 365. 1821.

This fungus has been known from ancient times on account of its medicinal properties and is still collected in considerable quantities in the larch forests of Europe and Asia for use in medicine. Single specimens are sometimes found weighing as much as fifteen pounds in the dry state. Many of the older botanists mention this plant. Bauhin (Pinax, 375. 1623) gives a good general description of it under the name "*Agaricum, sive fungus laricis.*" Micheli figures it (Gen. *pl. 61. f. 1.* 1729). Even Dioscorides knew its value. According to Miss Southworth, the substance of the fungus consists mostly of resin-granules about knots of mycelium, containing at times one or more curiously shaped bodies resembling branching bast cells, which grow out from the mycelium. These resin-granules contain the medicinal properties.

The European host of this fungus is the living larch. In America, it has been found also on pine and spruce. Specimens found in Michigan in 1886 on living white pine were used by Calkins and others instead of quinine. MacDougal collected a very handsome specimen on dead spruce in Montana in July, 1901. Macoun also found it on spruce in British Columbia in April, 1889. A recent note in Science from Professor Bessey refers to specimens received by him from Montana and the Yellowstone Park, collected on undetermined species of conifers. Calkins' report of this species in America a dozen or more years ago evidently escaped Professor Bessey's attention.

11. FOMES POPULINUS (Schum.) Cooke

Boletus populinus Schum. Enum. Pl. Saell. **2**: 384. 1803.

Poria obducens Pers. Myc. Eur. **2**: 104. 1825.

Polyporus connatus Weinm. Fl. Ross. 332. 1836. En. Stirp. Petrop. 208. 1837.

Polyporus connatus Fr. Epicr. 472. 1836–1838. Icon. *pl. 185. f. 2.*

Fomes connatus Gill. Champ. France, **1**: 684. 1878.

Fomes populinus Cooke, Grevillea, **14**: 20. 1885.

Finland (Karsten), Bavaria (de Thümen), Germany (Sydow), England (Massee), Sweden (Murrill), Canada (Dearness, Macoun), Georgia (Ellis), Ohio (James, Morgan), Delaware (Commons), New York (Earle, Underwood), Massachusetts (Underwood), Pennsylvania (Herbst), Florida (Martin), New Jersey (Ellis), Missouri (Glatfelter).

The favorite host of this species is the maple, though it is also found on poplar, linden and a few other deciduous trees. Living Norway maples in Sweden were found to be seriously injured by its attacks, and I have noticed it on this and other species of maple used as shade-trees in American cities.

12. **Fomes Meliae** (Underw.)

Polyporus Meliae Underw. Bull. Torrey Club, **24**: 85. 1897.

Described from specimens collected by Underwood on branches of *Melia Azederach* in 1895. It also occurs on *Gleditsia* and *Fraxinus*, as is indicated by the recent Alabama collections of Earle and Baker.

13. **Fomes rubritinctus** sp. nov.

A large perennial plant of many layers, the upper partly dead and discolored, the lower smooth, light-colored and anoderm with large pores, which become dark red when bruised. Pileus corky to woody, dimidiate, convex, 4–12 × 5–15 × 3–10 cm.; surface anoderm, smooth, velvety to the touch, white or pallid, becoming dark brown and roughened with age; margin obtuse, sterile, concolorous: context corky, becoming woody, pallid, 1.5 cm. thick: tubes unevenly stratified, the layers separated by unusually thick cushions of context, 0.5–1.0 cm. long each season, 2 to a mm., isabelline within, becoming umbrinous in the older layers; mouths subcircular or polygonal, edges thin, isabelline, becoming dark red when bruised: spores ovoid to globose, 5–7 μ long, smooth, hyaline, wall of medium thickness, hyphae hyaline.

Collected by C. L. Smith in Nicaragua and distributed as no. 138 of his Central American Fungi.

SPECIES INQUIRENDAE

Fomes geotropus Cooke, Grevillea, **13**: 119. 1884 (*Polyporus geotropus* Cooke, Grevillea, **13**: 32. 1884). This species is allied to *Fomes ulmarius* Fr. It was described from collections in Demerara, but seems to range northward to Mexico, Florida and Alabama. Other doubtful or unknown species are: *Fomes perpusillus* (Pers.) Cooke, *F. extensus* (Lév.) Cooke, *F. aegerita* (Fr.) Cooke, *F. microporus* (Sw.) Cooke, and *F. albogriseus* Peck.

NEW YORK CITY.

Four new Species of Grasses from Washington

By C. V. Piper

Elymus curvatus

Culms erect, often geniculate at base, about one meter high, glabrous; nodes glabrous: culm-leaves four or five; sheaths glabrous, the upper exceeding the internodes, the lower ones usually shorter; ligule none; blades flat, 15–20 cm. long, 5–7 mm. wide, scabrous on both sides, especially beneath: spikes stout, erect, barely exserted from the uppermost sheaths, 10–12 cm. long, green: empty glumes lanceolate, rigid, thick, 3–5-nerved, scabrous on the margins and on the nerves above the middle, acuminate, 13–17 mm. long, often curved or twisted, shining: spikelets 2–4-flowered, mostly 3-flowered: flowering glumes pale, 3–5-nerved near the apex, sparsely hispidulous above the middle, oblong-lanceolate, acuminate, 8–10 mm. long, tipped with a straight awn 1–2 mm. long: palea hardly equalling the flowering glume, scabrous-ciliate: internodes of the rachis 4–7 mm. long, scabrous on the nerves, apex and margins.

A peculiar species not closely related to any other known to me. Collected by Mr. Frank O. Kreager, no. 375, in Box Cañon, Pend Oreille River, Stevens County, Washington, Aug. 2, 1902.

Sitanion velutinum

Culms tufted, erect, rigid, densely puberulent, 30–40 cm. high: innovations few, short: sheaths exceeding the internodes, rather closely fitting, open in the throat, densely and minutely velutinous; blades flat, lanceolate, gradually attentuate from base to apex, acute, erect or divergent, densely puberulent on both sides; culm-leaves three or four, the lower 6–10 cm., the upper 2–4 cm. long; ligule obsolete: spikes well exserted, stiffly erect, 4–8 cm. long without the awns: spikelets two at each node or rarely one, the lower 1–2-flowered and frequently sterile, the upper 2–4-flowered, one to three of the florets fertile: empty glumes subulate, puberulent, 5–7 mm. long, mostly entire, but one or two often cleft and bearing a short lateral awn or rarely cleft to the base, each tipped with a scabrous spreading awn 3–5.5 cm. long: flowering glumes lanceolate, puberulent, 9–11 mm. long, 3-nerved above, trifid, the lateral lobes 1 mm. long, the stout awns 3–5.5 cm. long: palea as long as the flowering glume, acute, scabrous on the nerves:

internodes of the rachis linear-clavate, 4–6 mm. long, puberulent near the apex, minutely scabrous on the margin above.

Steptoe, Whitman County, Washington, collected by G. R. Vasey, July 5, 1901.

Sitanion basalticola

Densely tufted, the whole plant smooth and glaucous: culms 10–20 cm. high, barely exceeding the leaves of the numerous innovations: sheaths exceeding the internodes; ligule obsolete; blades involute, erect or recurved, 3–10 cm. long, 2 mm. wide, smooth beneath, minutely scabrous on the nerves above: spikes 3–5 cm. long, without the awns, erect, barely exserted from the upper sheaths: spikelets two at each joint, the lower with one sterile floret, the upper with three florets, two of them usually fertile: empty glumes or divisions mostly six or eight, subulate, entire, scabrous, about 6 mm. long, each tipped with a spreading awn, 2–3.5 cm. long: flowering glume 8–10 mm. long, glabrous and glaucous, excepting the three nerves at apex, these scabrous, the lateral ones prolonged into bristles 1 mm. long, the middle one into a stout scabrous divergent awn, 3–3.5 cm. long: palea as long as the flowering glume, minutely scabrous on the margin above the middle, emarginate at apex: internodes of the rachis flattened, linear or linear-spatulate, scabrous on the margins above.

In basaltic soil, Coulee City, Washington, collected by the writer, June 1, 1902, no 3924.

Sitanion rubescens

Culms tufted, erect, somewhat geniculate at the lower nodes, glabrous, about 60 cm. high; nodes brown: sheaths mostly shorter than the internodes, rather closely fitting, glabrous; ligules obsolete or nearly so; blades flat, green, linear, attenuate to the acute apex, 5–10 cm. long, 3–5 mm. broad, glabrous above, scabrous on the nerves beneath, where the latter are more prominent than above: spikes long-exserted, straight or flexuous, erect, 8–13 cm. long: spikelets mostly two, rarely three, at each joint, the lower or lateral ones 1–2-flowered, mostly sterile, the upper or middle ones 2–3-flowered, the lower one or two florets fertile: empty glumes lanceolate, frequently oblique, 2–3-nerved, scabrous on the nerves, 6–7 mm. long, each bearing a stout divergent scabrous awn, 1–2 cm. long, or the glumes very rarely bifid and bearing in addition a short lateral awn: flowering glumes lanceolate, 10–12 mm. long, smooth and shining below, 3–5-nerved and scabrous above, each bearing a stout straight or flexuous scabrid purplish awn, 1.5–5 cm. long: palea as long as the flowering glume, truncate, scabrous on the nerves above: internodes of the rachis spatulate, flattened, scabrous on the margins, 6–8 mm. long.

Dry rocky places, 2300 m. altitude, Mount Rainier, Washington, collected by the writer, in August, 1895, no. 1954. This species is nearest allied to S. *lanceolatum* J. G. Smith.

PULLMAN, WASHINGTON.

New Plants from Colorado

By George E. Osterhout

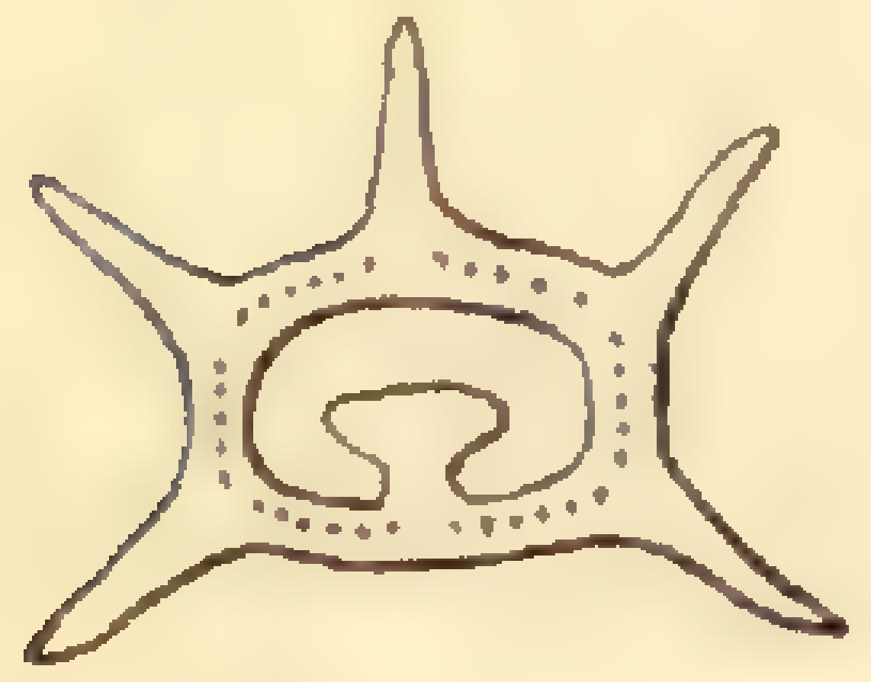
Cryptanthe gracilis

Annual: stem branched, erect, slender, 1–1.5 dm. high, sparsely hispid; leafy to the inflorescence, but the leaves rather few and remote, narrowly oblanceolate and rounded at the apex, about 1 cm. long, sessile, hispid on both surfaces but not densely so: inflorescence pedunculate, scorpioid, from the ends of the branches: flowers small: corolla white: fruiting calices becoming rather remote; lobes slender, having no noticeable midrib, densely hispid with whitish hairs, attaining a length of 3 mm.: nutlet solitary, narrowly ovate, acuminate, smooth, triangular in cross section, but not sharply angled, 2 mm. long, a little longer than the large gynobase to which it is attached for about half its length.

Collected only at Glenwood Springs, Garfield Co., Colo., June 6, 1902, no. 2589.

Aulospermum planosum

Perennial from a long fleshy root: stem naked with scarious sheaths at base, 5–7 cm. high, crowned by the leaves and peduncles which stand at right angles to the stem, making the top somewhat flat: leaves glaucus, ovate in outline, 7–8 cm. long, on rather long peduncles, bipinnatifid, the divisions mostly entire, but some of them lobed: peduncles longer than the leaves: involucre none: bracts of the involucels few and linear: umbel of 6 or more rays, 2–3 cm. long: pedicels about 2 mm. long: flowers purple: fruit oblong, 6 mm. long, broadly winged, oil tubes 5–6 in the intervals, 10–12 on the commissure.



Collected along the Eagle River at Minturn, Eagle Co., Colo., June 5, 1902, no. 2572.

Touterea multicaulis

Perennial, many-stemmed and much branched: stems whitish, smooth and shining, but slightly hispid at summit, 2–3 dm. high: lower leaves including the short petiole about 0.5 cm. long, pinnatifid, the divisions remote and entire; upper leaves narrowly linear, entire and sessile: flowers numerous from the ends of the branches, opening at sundown or a little before, and closing again in about half an hour: peduncles short: calyx-lobes deltoid, acuminate, almost 1 cm. long: petals 5, golden yellow, 1.75 cm. long including the short claw: several of the outer filaments petaloid: capsule appressed-hispid, 1 cm. long: seeds round, smooth, 2.5 mm. in diameter, margined but not winged.

Type specimens collected at Wolcott, Eagle Co., Colo., July 11, 1902, no. 2663. It is found from the Eagle River at Wolcott northward to the Grand River.

Lepidium divergens

Seemingly a biennial, 1.5–2 dm. high, much branched from the base, the branches divergent and procumbent, attaining a length almost equal to the central upright stem: stem, branches and pedicels minutely pubescent: lower leaves spatulate, 2–5 cm. long, rounded or acute and few-toothed above, tapering to a narrowly winged petiole, diminishing upwards and becoming entire: stem and branches becoming fruit-bearing for two thirds of their length or more: pedicels horizontally spreading, about 3 mm. long: flowers small: petals none: sepals soon deciduous: stigma sessile: capsule emarginate, elliptical, 3 mm. long by 2.5 mm. wide: cotyledons incumbent.

Type specimens collected at Tennessee Pass, Lake Co., Colo., July 10, 1902, no. 2642. Collected also at Yampa and Steamboat Springs in Routt Co., Colo.

New Windsor, Colo.

New Species of Oreocarya

By Alice Eastwood

In 1892 and 1895 the author collected several species of *Oreocarya* in Colorado and Utah which differed from each other and did not agree with any of the then described species. These were laid aside on account of more pressing work. Some of these have since been described by Dr. E. L. Greene and Professor Aven Nelson; but there still remain several which apparently have not come under the observation of these botanists, while others are to be found in the herbarium of the California Academy of Sciences which, in the opinion of the author, have been incorrectly assigned to species from which they differ sufficiently to be considered distinct.

Duplicates of types of many of the species are in the Academy's herbarium and I have besides, through the kindness of Mr. Carl F. Baker, had the opportunity of examining others which we did not possess.

Oreocarya disticha

Stems several from a woody perennial root, erect, slender, about 3 dm. high, with few erect branches, canescent with fine short closely appressed pubescence and few longer appressed bristly hairs: radical leaves wanting but the remains of the broad sheathing petioles indicating a cluster; cauline leaves somewhat scattered, oblanceolate, tapering to margined petioles which are dilated and clasping at base, upper surface appressed-pubescent, lower appressed-hirsute and pustulate, acute, entire, of falcate outline when the edges are folded together, 2–4 cm. long: panicle becoming 8 cm. or more long, pedunculate, branching into a few slender spikes, with the flowers close and distichous on pedicels less than half as long as the sepals; bracts linear, but little surpassing the pedicels, the upper ones very small: divisions of the calyx involute, keeled, ovate-lanceolate, 4 mm. long, conniving around the fruit but with the obtuse tips spreading, pubescence like the stem: corolla white; limb with the divisions obovate-oblong, entire, obtuse, extending almost to the throat, a little more than 2 mm. long and almost as wide, about 5 mm. shorter than the tube; tube constricted at base and throat with the crests in the throat half as long as the anthers, those at base forming a moniliform ring that closes around the style above the ovary: stamens inserted in the throat, the upper part of the anthers alternating with the crests: fruit with but one nutlet maturing, this sharply keeled on the ventral side, rounded and arched on the dorsal, acutely margined, depressed, mottled dark and light brown, glossy, slightly roughened with a few scattered papillae.

This is to be included in the group formerly under *Krynitzkia Jamesii* Gray. It was reported with that name (no. 90) in my Report on a Collection of Plants from San Juan County, Southeastern Utah, Proc. Cal. Acad. Sci., II. **6**: 311. It was collected by the writer on the mesa above the San Juan River, Utah, on what was known as Barton's Range, July 13, 1895. It differs from *O. suffruticosa* (Torr.) Greene, in habit, pubescence, flowers and seeds. In habit of growth it more closely resembles *O. multicaulis* (Torr.) Greene, but differs in the size of the flowers, the number and appearance of the nutlets.

Oreocarya Lemmoni

Stems several from a branched caudex, about 10–15 cm. high, rather stout and leafy, floriferous throughout, densely yellowish or white tomentose and hairy with long fine white soft hairs, neither striate nor ribbed: leaves linear-oblanceolate, obtuse, with no distinction of petiole and blade; the lowest 9 cm. long, diminishing to the bracts, 1 cm. long, 2–5 mm. wide, tomentose and but slightly hairy: inflorescence with axillary clusters capitate on peduncles 5–10 mm. long; bractlets long, surpassing the sessile or short-pedicelled flowers; terminal spikelets aggregated into capitate clusters (in flower): divisions of calyx ovate-acuminate, almost as long as the corolla, 4 mm., densely tomentose and sparingly hairy: corolla white; tube campanulate, broadening from a base 1 mm. in diameter to the throat more than 2 mm. across, 2.5 mm. long; lobes orbicular, extending almost to the throat, 2 mm. wide; crests in throat conspicuous, 1 mm. wide at base, bilobed at apex, fleshy; crests at base small, forming a moniliform ring less than 1 mm. from the base: stamens with oblong anthers, attached below the middle of the tube by very short broad filaments, the apex reaching the base of the crests in the throat: nutlets immature but apparently smooth and depressed like *O. suffruticosa* Greene.

This is well distinguished from all other members of the group and from all other species of the genus by the peculiar shape of the corolla. All others that are known are distinctly salverform while this approaches the rotate form. It was collected by J. G. Lemmon, in whose honor it is a pleasure to name it, in Arizona, without definite locality, 1884. The type is in the Herbarium of the California Academy of Sciences.

Oreocarya celosioides

Stems stout, apparently simple from a leafy caudex which is clothed with the broad imbricated petioles of former leaves, 8 mm. in diameter, more than 4 dm. high, floriferous from above the middle, leafy, striate, setose-hispid with stiff tawny or white bristles and pubescent beneath the bristles with dense intricately appressed pubescence; radical leaves mostly wanting, the persistent bases of the petioles remaining, these about 6 mm. broad, densely clothed with fine white appressed hairs and ciliate with spreading white bristles; the one or two small persistent leaves spatulate with petioles 2–3 times longer than the blades, together 3 cm. long, pubescence as on the stem, except that the bristles are pustulate at base; cauline leaves linear-lanceolate, 2–4 cm. long, 3–4 mm. wide, sessile, hispid with numerous very stiff bristles: inflorescence of thick, densely clustered, unilateral spikes, elongating upwards; bractlets conspicuous, linear, shorter than the calyx: calyx about equalling the tube of the corolla, densely setose with yellowish bristles; divisions linear-lanceolate, 5 mm. long in flower, becoming 15 mm. in fruit, conniving over the nutlets but with the foliaceous tips free: corolla white with orbicular divisions extending to 1 mm. of the throat, 4 mm. long and of equal width; tube 5 mm. long, with the crests in the throat small, obtuse, less than 0.5 mm.; scales at base forming a moniliform ring above the ovary, less than 1 mm. from the base: anthers oblong, 1.3 mm. long, not quite reaching the crests; filaments short and broad, inserted about the middle of the tube: nutlets erect, acute, slightly cordate at base, keeled on the dorsal side and with the narrowly winged margins elevated so that there is a shallow concavity between the ridge and the continuous margin, 5.5 mm. long, 3 mm. wide, rugose with transverse ridges and fine papillae between; scar shallow and narrow, not extending to the apex nor forked at base, nor extending to the very base; gynobase subulate, 5 mm. long, attached for almost its entire length.

This approaches *O. setosissima* (Gray) Greene. It differs in the denser inflorescence, resembling somewhat that of *Celosia cristata* L., its larger flowers and different nutlets. It was distributed as *Eritrichium glomeratum* DC. by Thos. J. Howell, from the banks of the Columbia River, eastern Washington, July, 1881.

Oreocarya elata

Stems one to several from a woody tap-root, 3–4 dm. high, virgate, ribbed, floriferous from near the base with sessile or peduncled clusters which form heads of few to several flowers in the somewhat distant leaf-axils, later becoming spikes; summit of the stem branched, forming a panicle of unilateral bracteate spikes which are at first capitate but later lengthen, the lower flowers becoming distant more than their own length: pubescence of lower part of stem and leaves snowy white, consisting of densely appressed and interlaced fine hairs with some scattered appressed bristles mostly pustulate at base; pubescence of the upper leaves and inflorescence tawny and more spreading: radical leaves densely clustered on the caudex, spatulate, entire or crenate, acute or obtuse, with the margined petioles as long as the blade, together 2–3 cm., strongly ribbed; cauline leaves distant from each other 1–3 cm., lanceolate, together with the broad margined clasping petioles 2–4 cm. long, 5 mm. wide: divisions of the calyx ovate with strong midvein, 4 mm. long, 2 mm. wide at base, densely hispid, surpassing the tube of the corolla, enlarging in fruit, conniving over the nutlets but with the tips spreading: corolla white; tube 3.5 mm. longer than the orbicular lobes which do not extend to the throat; crests slightly emarginate, fleshy, arching over the elliptical anthers; basal scales crescent-shaped, forming a ring 1 mm. from the base: anthers 1.5 mm. long, 1 mm. wide, on short broad concealed filaments: nutlets erect, ovate, with the lateral edges acutely margined but not winged, obtuse, tuberculate with glossy white tubercles which are separate or confluent in irregularly transverse ridges, especially along the middle of the dorsal surface: gynobase subulate; scar forked at base and extending almost to the apex.

This is nearest to *O. setosissima* (Gray) Greene from which it differs in all its parts. It was collected by the author near Grand Junction, Colorado, on the road to the coal mines, growing on the bare clay hills characteristic of the region, flowering May 15, fruiting June 28, 1892.

Oreocarya aperta

Caudex branched from a woody root, with leaves densely clustered at base and the dilated petioles imbricated: stems several, rather slender, 1–2 dm. high, branching from near the base with many spreading simple or 2-forked spikes, those of all the stems aggregated into a closely branched thyrse: pubescence gray, setose-hispid, the spreading white bristles pustulate at base, 2–3 mm.

long, the surface under the bristles clothed with fine white densely and intricately appressed hairs : radical leaves spatulate to oblanceolate, together with the margined petioles 3 cm. long, 8 mm. wide, the midrib forming a ridge on the lower surface ; cauline leaves oblanceolate, about as long as the radical leaves but narrower : spikes peduncled, longer than the subtending leaves, distichous or unilateral ; bractlets linear, longer than the internodes, shorter than the mature calyx ; pedicels very short, about 0.5 mm. long : divisions of the calyx subulate-acuminate, equalling the tube of the corolla in flower, elongating from 3–10 mm., strongly ribbed, densely setose, not conniving over the nutlets but spreading open and becoming campanulate, readily disarticulating from the peduncles when the seed is ripe, leaving an umbilicate scar at the base of each spreading bractlet : corolla white ; tube equal to the limb, together 6 mm. long; divisions not extending to the throat, obovate with the apex obcordate or obtuse, 2.5 mm. broad, margin obscurely sinuate ; crests conspicuous, 1-nerved, truncate, 0.5 mm. long and as broad ; crests at base less than 1 mm. from the bottom, forming a moniliform ring of 10 nipple-like projections around and above the ovary : anthers oblong, 1.25 mm. long, concealing the short broad filaments and extending to the base of the crests : nutlets erect, 2.5 mm. long, ovate, obtuse, the dorsal ridge prominent, acutely margined all around ; scar sulcate, extending almost to the apex, not forked at base, rough with glossy white papillae which are confluent into small papillae, becoming somewhat star-shaped in outline, the smaller papillae intervening : gynobase linear-subulate.

This is near *O. thyrsiflora* Greene, but is entirely distinct. It was collected by the author at Grand Junction, Colorado, June 27, 1892.

Oreocarya Wetherillii

Biennial from a slender tap-root, the caudex densely clothed with the petioles of former leaves, branched from the base with one stout stem and one or more low slender ones, 1–3 dm. high : leaves and stem white with densely appressed interlaced fine hairs and spreading bristles pustulate at base : radical leaves spatulate, obtuse or acute, with blades as long as the broad margined petioles, which are dilated and imbricated at base, 1–3 cm. long, 5–10 mm. broad : glomerule extending from the base, consisting of numerous unilateral or distichous spikes with oblong sessile bracts diminishing upwards ; bractlets linear-lanceolate, equalling or surpassing the calyx : calyx of 5 narrow, linear divisions, 5 mm. long, densely hispid with white bristles, which are tawny in bud, in fruit conniving over the nutlets but with spreading tips, becoming 1 cm. long: corolla white with orbicular lobes not extending to the throat, nor so long as the tube, together equalling 6 mm.; the tube surpassing the calyx in flower; crests hispid, rounded, base of tube without scales or crests: anthers linear-oblong, inserted below the crests on short subulate filaments which are concealed by the anthers: nutlets erect, ovate-oblong, 2 mm. broad, 3–5 mm. long, obtuse, acutely margined on the lateral angles, inserted almost the entire length, rarely all maturing; scar scarcely forked at base, when ripe the surface brown, covered with glossy white, irregular, minute, often confluent tubercles: gynobase elongated-subulate.

This showy species is related to *O. thyrsiflora* Greene but differs in the naked base of the corolla-tube, the hispid crests in the throat, and in the longer tube of the corolla. It was collected by the author in flower and fruit, May 25, 1892, in Court House Wash, near Moab, southeastern Utah. It is named in honor of Mr. Alfred Wetherill who was my guide and companion on the trip when it was discovered.

Oreocarya nana

Stems low, caespitose, 5–10 cm. high, 3–several from a slender tap-root, the simple or branched caudex densely covered with the petioles of former leaves, hispid throughout with spreading white or yellowish bristles which are frequently pustulate at base, striate, floriferous almost from the base: radical leaves crowded on the caudex, white with closely appressed hairs mixed with coarser bristles, oblanceolate, petiolate, acute, 1–2 cm. long, 2–5 mm. wide; cauline leaves few, similar to the radical but shorter, the appressed hairs tawny, the bristles white and more spreading: inflorescence spicate-glomerate, 4 cm. long, 1–2 cm. wide: flowers 1–3 in the axils of the linear bracts, with pedicels shorter than the bracts, half as long as the calyx: divisions of calyx linear-subulate, longer than the corolla-tube, 4.5 mm. long, enlarging in fruit and conniving over the nutlets, outer surface densely clothed with spreading yellow bristles, inner with the bristles appressed: corolla white, the tube shorter than the limb; divisions broadly oval to orbicular, not extending to the throat, 3 mm. long, equalling the tube; crests in the throat prominent, rounded, half as large as the anthers; crests at base nipple-like, in pairs, 1 mm. from the bottom: anthers on scarcely perceptible subulate filaments, oblong, 1 mm. long, inserted below the crests in the throat: nutlets 1–2 maturing, erect, ovate, obtuse, keeled on the dorsal side and rough with sharp transverse interrupted muriculations, having fine papillae intervening; ventral surface with coarser papillae; scar open and broad like a furrow, forked at base, reaching within 0.5 mm. of the apex: gynobase elongated-subulate.

This is perhaps nearest to *O. caespitosa* A. Nelson from which it differs in fruit and floral organs as well as habit and pubescence. It was collected by the author near Grand Junction, Colorado, on the mesa above the Gunnison River, May 17, 1892.

Oreocarya cristata

Caudex with many branches from a slender woody tap-root, apparently perennial; stems slender, about 2 dm. high, ribbed, not floriferous at base, pubescent with appressed tangled hairs and fine spreading white bristles which are 2 mm. long: leaves oblanceolate-spatulate, with broad petioles dilated at base, the lower ones twice as long as the blades, the upper about equalling them, together 1.5–5 cm. long; blades 6 mm. broad; petioles 4 mm. broad at base; pubescence on younger leaves tawny, that on older ones cinereous with appressed hairs and bristles, the latter pustulate at base; pubescence of inflorescence gray or tawny: inflorescence a compound spike or glomerule, little more than half as long as the stem; peduncles 2–4 mm. long; pedicels about 1 mm. long: spikelets 2–4-flowered: calyx of five lanceolate very bristly divisions 6 mm. long, not enlarging much in fruit, shorter than the tube of the corolla, with pubescence gray or tawny: corolla with broad orbicular divisions, not extending to the throat, 4 mm. broad; tube almost 1 cm. long; crests in throat conspicuous, oblong, 1 mm. long, without scales or crests at base: anthers oblong, more than 2 mm. long, almost sessile, the apex 1 mm. from the base of the crests: nutlets globose, incurved, ovate, acutely margined to the scar, rough with transverse ridges and minute papillae intervening; scar broad and open, with open, forking base: gynobase mitriform.

This is peculiar in the broad limb of the corolla with orbicular lobes, the prominent crests in the throat of the corolla-tube, and the peculiar nutlets of which one was generally abortive. This was collected by the author at Grand Junction, May 17, 1892.

Oreocarya tenuis

Caudex densely clothed with dry imbricated petioles, much branched from a woody tap-root having a dark brown epidermis: stems many, slender, erect, 1–2 dm. high, ribbed, floriferous from near the base with few scattered flowers or clusters, above becoming a panicle of pedunculate spikes, grayish throughout with a rough pubescence of closely appressed hairs and some scattered white bristles which are pustulate at base: leaves spatulate-oblanceolate, tapering to broad petioles which exceed the blade and are dilated and clasping at base, together with the blade 1–3 cm. long, 2–5 mm. broad, acute, entire but bristly ciliate, appressed-hispid on the upper surface, lower surface with bristles as on the stem, the midrib forming a ridge through the center: internodes 1–2 cm. long: spikes peduncled, few-flowered (2–5); pedicels 1–3 mm. long, with or without bractlets, which when present surpass the pedicels: calyx shorter than or equalling the tube of the corolla, with linear-acuminate divisions 6 mm. long, hispid with spreading bristles, the margins whitened by densely appressed white hairs: corolla white; tube 5 mm. long, exceeding the border by 1 mm.; divisions oblong, 3 mm. long, 2 mm. wide, obtuse, not extending to the throat; crests in the throat bisected by a central ridge, short and broad: anthers linear-oblong, 1.5 mm. long, inserted about the middle on short broad filaments, the apex about on a level with the top of the crests; no scales or crests at base of tube: nutlets ovate, obtuse, 3 mm. long, 2 mm. wide, acutely margined except below the scar; dorsal surface keeled, corrugated-rugose with the epidermis pale gray and lucid; scar broadest at the middle and with broad bifurcation at base: gynobase mitriform, 4-angled.

This peculiar species is distinguished from all others by the more slender stems and more contracted inflorescence. Its long corolla-tube marks it as distinct from any of the group formerly included under *O. glomerata.* It was collected by the author near Moab, in Court House Wash, southeastern Utah, May 25, 1892. It grew in red sandy soil.

Oreocarya Shockleyi

Stems several from a tufted branching caudex which is densely clothed with dry imbricated petioles of former leaves, 1–2 dm. high, leafy, striate, not more than 2 mm. in diameter, floriferous from the middle, cinereous with downwardly appressed pubescence and spreading fine white silky bristles which are 1–2 mm. long: leaves on caudex oblanceolate, tapering to a broad petiole which is dilated and ciliate at base, strongly ribbed, together with the blade 3–6 cm. long, 3–7 mm. wide, cinereous with fine, white appressed pubescence and fine scattered bristles with papillae at base which dot the surface; cauline leaves linear-oblong or narrowly oblanceolate, sessile or with petioles more than half as broad as the blades: spikes consisting of short-peduncled spikelets or heads, containing from two to five sessile flowers, the lower clusters somewhat distant, the upper becoming almost capitate: bracts, the diminished upper leaves; bractlets linear, about equalling the divisions of the calyx: calyx 7 mm. long, shorter than the tube of the corolla, with lanceolate-acuminate divisions 6 mm. long, ribbed, with the pubescence yellowish, appressed and bristly, densely so on the outer surface and the foliaceous tips of the inner, the lower part conniving over the nutlets: corolla white, the tube twice as long as the limb, 9 mm.; divisions orbicular, 4 mm. long and wide, crenate-sinuate; crests truncate, slightly emarginate, minutely papillate, 1 mm. long; no crests or scales at base of corolla-tube: anthers linear-oblong, almost 2 mm. long; on short broad filaments, inserted below the middle of the anthers, the apex reaching to 1 mm. below the crests: nutlets ovate, 4 mm. long, dorsal side arched and keeled; surface rough with pointed muriculations like microscopic mountain peaks and with fine vermiculate elevated lines intervening, margined except at base, ventral surface with similar sculpture, the scar protuberant, extending from near the summit, broadening to the deep fork which is about 2 mm. across: gynobase conical, about 3 mm. high.

This well-marked species was collected by W. H. Shockley, in whose honor it is named. It was collected in gulches on Miller Mountain, Esmeralda County, Nevada, at an elevation of 7500 ft. It is No. 244 of Mr. Shockley's collection, distributed as *Krynitzkia fulvocanescens* Gray.

CALIFORNIA ACADEMY OF SCIENCES.

Studies on the Rocky Mountain Flora.—X

By Per Axel Rydberg

Corispermum marginale sp. nov.

Annual: stem glabrous, much branched, 2–5 dm. high: leaves narrowly linear, 2–5 cm. long, 1.5–2 mm. wide: spike 3–8 cm. long, rather dense; bracts usually overlapping each other, the lower lanceolate, about 1 cm. long, the upper ovate, 5 mm. long; all more or less acuminate, with a strong midrib and conspicuous scarious margins, slightly pubescent when young or glabrate: fruit about 4 mm. long and 2.5 mm. wide, with a broad wing margin.

This is perhaps most nearly related to *C. hyssopifolium* of the salt marshes of the coast regions, but is taller, more slender, with less fleshy leaves, smaller fruit and more conspicuously scarious-margined bracts. From *C. nitidum* it differs in the broader bracts, denser spikes and larger fruit. It grows in similar localities, viz., in sandy soil, in draws and ravines.

New Mexico: Albuquerque, 1884, *C. L. Herrick* (type in herb. N. Y. Bot. Garden).

Colorado: Huerfano Valley, near Gardner, 1900, *F. K. Vreeland, 657;* Rocky Ford, 1893, *Crandall;* Denver, 1887, *S. M. Tracy.*

Chenopodium Watsoni A. Nelson, Bot. Gaz. **34**: 362. 1902

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, mainly. Not Curt.

Annual, rather stout, sparingly farinose, 2–6 dm. high: stem branched, striate and sometimes tinged with red: leaves rather thick; petioles 2–10 mm. long; blades 1–2 cm. long, oval, ovate or oblong, obtuse and occasionally cuspidate-mucronate, dark green and sparingly mealy: inflorescence narrow, dense: flowers 1 mm. in diameter: seed 1.25–1.5 mm. in diameter: pericarp mealy and closely adherent.

Watson's name being preoccupied, I apply Nelson's substitute to this species as it is Watson's *C. olidum* as to the description and most specimens cited. Several specimens given by him belong, however, to the next species, which has been confused with it. Mr. Powell sent some seeds to Elihu Hall. A specimen raised from these seeds and preserved in the herbarium of Columbia University I take as typical *C. Watsoni.*

Chenopodium Wolfii sp. nov.

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, partly.

Annual, sparingly mealy: stem erect, 3–4 dm. high, often branched, striate: leaves moderately thick, dark green, only slightly mealy; petioles about 1 cm. long; blades 1–3 cm long, oblong to ovate-lanceolate, entire or rarely slightly hastately toothed, obtuse: inflorescence dense, narrow: flowers small: seeds less than 1 mm., usually .75 mm. in diameter: pericarp thin and easily separated from the seed.

Closely resembling the preceding in habit, but is easily distinguished by the smaller flowers and seed and the separating pericarp. These characters place it nearest to *C. oblongifolium* Nutt., from which it differs in the less mealiness and the smaller seeds.

COLORADO: Twin Lakes, 1773, *John Wolf, 253*, apparently also *258* and *263*.

WYOMING: Wamsutter, 1897, *Aven Nelson, 3671.*

Endolepis ovata sp. nov.

Low, annual, usually less than 1 dm. high: stem branched, straw-colored or pinkish, almost glabrous: leaves subsessile, usually less than 1 cm. long, ovate or lance-ovate, 3-nerved at the base, sparingly mealy: pistillate flowers solitary in the axils of the middle leaves: staminate flowers in small clusters in the axils of the upper leaves or at the end of the branches, otherwise as in *E. Suckleyana* Torr.

In my opinion Dr. Torrey was correct in separating *Endolepis* from *Atriplex*. It is interesting to find a second species of the former genus, which hitherto has been known as monotypic. The original *Endolepis* has narrowly lanceolate leaves, which are thinner and without lateral ribs.

WYOMING: Buffalo, 1900, *Frank Tweedy, 3290* (type in herb. N. Y. Bot. Garden); Wallace Creek, 1898, *Elias Nelson, 4999*; Rock Creek Station, 1881, *L. F. Ward.*

MONTANA: Glendive, 1892, *J. H. Sandberg.*

Cleomella cornuta sp. nov.

Annual: stem straw-colored, 2–3 dm. high, branched below with ascending branches, glabrous throughout: leaves ternate; petioles 1–1.5 cm. long; leaflets 1–2 cm. long, oblong or oblong-oblanceolate, obtuse, mucronate: inflorescence short: pedicels very slender, almost 1 cm. long: sepals yellowish, ovate, cuspidate, less than 1 mm. long: petals light yellow, narrowly oval, clawless, about 3 mm. long: filaments about twice as long: fruit broadly rhombic, broader than long, about 3 mm. long and 4 mm. broad; the corners often produced into short processes: stipe 6–8 mm. long; beak over 1 mm.: seeds about 2.5 mm. long, 1.75 mm. wide, smooth and unmarked.

This is related to *C. oocarpa* and *C. plocasperma*, but has broader leaflets. From the former it also differs in the strongly rhombic pod and from the latter in the broader and unmarked seeds. The type grew at an altitude of 1350 m.

UTAH: Cainsville, 1894, *Marcus E. Jones, 5656* (type in U. S. Nat. Herb.).

Cerastium Earlei sp. nov. ✓

Perennial with a slender branched and stoloniferous rootstock: stems weak, ascending, 2–3 dm. high, viscid-puberulent, branched: leaves oblong or oblanceolate, obtuse, viscid-puberulent, 1.5–3 cm. long, 3–8 mm. wide: inflorescence open; bracts ovate or ovate-lanceolate, not scarious; pedicels 2–2.5 cm. long: sepals lanceolate, acute, sparingly pubescent, scarious on the margins, about 5 mm. long: petals about 1 cm. long or more, fully twice as long as the sepals, not very deeply cleft.

The type number was determined by M. E. Jones as *Cerastium alpinum* near var. *glabratum*, and the other two numbers of the Baker, Earle and Tracy collection are labeled *Cerastium* ———, and *Cerastium arvense oblongifolium*, respectively. The six sheets (two of each number) in the N. Y. Botanical Garden herbarium (except one of number *621*, which represents a luxuriant state) are so alike that it is impossible to refer them to different species. In the size of the flowers, form of the leaves and general habit, the species resembles most *C. alpinum*, but the pubescence is different: in *C. alpinum* long-villous and less viscid, in *C. Earlei* very short and very viscid. The latter grows at an altitude of 2700–3600 m.

COLORADO: Near La Plata P. O., 1898, *Baker, Earle & Tracy,* *472* (type in Herb. N. Y. Bot. Garden); Little Kate Basin, La Plata Mts., *568;* Cumberland Basin, *621.*

✓ **Cerastium Leibergii** sp. nov.

Perennial with a slender, branched rootstock: stems simple, 4–5 dm. high, sparingly villous and viscid-puberulent; uppermost internode of the stem about 1 dm. long: leaves few and scarcely half as long as the internodes, linear-oblong, 2.5–3 cm. long, 6–7 mm. wide, the lower obtuse, the upper acutish, 1-nerved, thin, puberulent when young, ciliate on the margins: inflorescence viscid-puberulent; bracts lanceolate, 4–8 mm. long, not scarious-margined; pedicels in fruit 2.5–3 cm. long: sepals about 5 mm. long, lanceolate, viscid-pubescent, scarious-tipped and margined: petals scarcely twice as long as the sepals.

This is perhaps most nearly related to the preceding, but differs mainly in the broader, obtuse leaves and smaller flowers. It grows in open *Pinus ponderosa* forests at an altitude of 970 m.

IDAHO: Upper St. Mary's River, 1895, *J. B. Leiberg, 1103* (type in U. S. Nat. Herb.).

✓ **Cerastium graminifolium** sp. nov.

Perennial with slender branched rootstock: stems 3–5 dm. high, densely short-villous and somewhat viscid, erect; uppermost node of the stem below the inflorescence elongated, 5–10 cm. long: leaves linear-lanceolate, 2–3 cm. long, 3–5 mm. wide, 1-nerved, short viscid-villous, mostly spreading: bracts lanceolate or ovate-lanceolate: pedicels in fruit 2–4 cm. long: sepals narrowly lanceolate, densely viscid-pubescent, only slightly scarious-margined, acute, 5–6 mm. long: petals 12–14 mm. long, cleft ⅓–¼ their length into oblong, obtusish lobes: capsule almost straight, about ⅔ longer than the sepals.

This has gone under the name of *C. arvense*, but differs from the European plant, in the larger flowers, the more villous pubescence and the more acute leaves, which resemble much those of *Alsine graminea.* It grows in rich bottom lands.

WASHINGTON: Pullman, 1897, *Elmer, 177* (type in herb. N. Y. Bot. Garden).

IDAHO: near Lewiston, 1896, *A. A. & E. Gertrude Heller, 3013;* Upper Ferry, Clearwater Ferry, 1892, *Sandberg, MacDougal & Heller, 49.*

Draba sobolifera sp. nov.

A low cespitose perennial, but the leafy stolons often somewhat elongated: basal leaves oblanceolate, obtuse or spatulate, 1–2 cm. long and 3–4 mm. wide, sparingly stellate-villous, thick with indistinct midrib: peduncles 3–6 cm. long, stout, rather many-flowered: petals yellow, obovate, about 4 mm. long, more than twice as long as the rounded sepals: pedicels in fruit 7–8 mm. long: pod ovate, about 6 mm. long, 3–4 mm. wide, finely stellate: style about 5 mm. long. 0.5

This species is related to *D. ventrosa* and *D. alpina*. From the former it differs in the longer leaves and the finer and sparser pubescence; from the latter in the more elongated stems, the shorter and stellate pod and the shorter styles. It grows at an altitude of about 2500 m.

UTAH: Marysvale, above timber line, 1894, *Marcus E. Jones, 5936* (type), *5893e* and *5893az* (all in U. S. Nat. Herb.).

Draba argyrea sp. nov.

A cespitose tufted perennial, with underground horizontal stems; basal leaves obovate, 3–7 mm. long, in dense rosettes, densely and finely stellate, almost silvery; midvein indistinct: peduncles slender, 3–5 cm. long, naked, few-flowered: petals yellow, 3 mm. long, obovate, about twice as long as the ovate sepals: pedicels in fruit 5–8 mm. long: pods lanceolate, 6–7 mm. long, 2.5–3 mm. wide, minutely stellate: style about 1 mm. long.

This species resembles somewhat *D. oligosperma* in general habit and flowers, but the leaves are shorter and broader, more decidedly stellate and without the strong midrib, and the pod is longer. It also reminds one of *D. ventrosa* but is a more delicate plant with finer pubescence and longer pods. The type grew at an altitude of about 3000 m.

IDAHO: Rock crevices, Sawtooth Mountains, head of Pettit Lake, July, 1895, *L. F. Henderson, 3538* (type in U. S. Nat. Herb.).

Draba uncinalis sp. nov.

Small cespitose and pulvinate perennial: flowering stems scapiform, 2–3 cm. high, sparingly stellate, leafless; basal leaves in dense tufts, thick, rounded obovate, 3–4 mm. long, sparingly stellate, with indistinct midrib: inflorescence corymbiform, few-flowered; pedicels in fruit 4–5 mm. long: pod ovate, 3–4 mm. long and 3 mm. wide, glabrous or nearly so: style about 0.5 mm. long.

A small plant characterized by the short pod, found otherwise only in two North American species, viz., *D. andina* and *D. oligosperma ;* but in both of those species the leaves have strong midribs and are less stellate. In habit it resembles most *D. nivalis*, but that species has a different pod. It grows at an altitude of 3500 m.

UTAH : Marysvale, Tate Mine, 1894, *M. E. Jones, 5940am* (type in U. S. Nat. Herb.).

✓ **Lesquerella Utahensis** sp. nov.

A tufted perennial : stems ascending, 5–10 cm. (seldom 15 cm.) high ; basal leaves 3–4 cm. long, petioled ; blades oval or obovate, densely and finely stellate ; stem-leaves smaller, oblanceolate or spatulate : petals yellow, about 8 mm. long, with cuneate blades, ½ longer than the oblong sepals : pedicels in fruit ascending, 5–10 mm. long : pod almost spherical or slightly transversely flattened, 3–4 mm. wide, finely stellate : style 4–5 mm. long, much longer than the pod.

This species is related to *L. Wardii*, *i. e.*, it has the same habit and pubescence and the pod is as in that species somewhat thicker than broad ; but the latter is shorter, rounder, neither elongated nor acute at the apex. *L. Utahensis* grows at an altitude of 2000–3500 m.

UTAH : American Fork Cañon, 1880, *Marcus E. Jones, 1354* (type in herb. N. Y. Bot. Garden) ; Friser, 1880, *1810 ;* Marysvale, 1884, *5375e, 5958n ;* Irelands Ranch, Salina Cañon, *5441 ;* Cañon above Tropic, *5312d.*

✓ **Stanleya runcinata** sp. nov.

Stem stout, glabrous : basal leaves about 2 dm. long, lanceolate in outline, runcinately divided, softly pubescent with long white hairs ; lobes broadly triangular or the lowest ones oblong : stem-leaves ovate to oblanceolate, more glabrous : raceme 1–3 dm. long, many-flowered : sepals linear, about 1 cm. long and 1 mm. wide, light yellow, glabrous : petals about ¼ longer ; blades oblanceolate, about ⅔ as long as the glabrous claws : filaments glabrous, about twice as long as the sepals : pods almost erect and straight, 6–7 cm. long, 1.5 mm. wide, on spreading pedicels about 1 cm. long.

This species is perhaps most closely related to *S. pinnata*, but easily distinguished by the lobing of the basal leaves, the straight pods, the oblanceolate blades of the petals and the glabrous filaments.

IDAHO (?): 1896, *Henderson* (type in U. S. Nat. Herb.).

✓ **Thelypodium ovalifolium** sp. nov.

Perennial, perfectly glabrous: stems terete, 3–5 dm. high, ascending: earliest basal leaves about 5 cm. long, petioled with broadly oval blades, glabrous, entire, obtuse; the later ones oblanceolate; stem-leaves sagittate, 2 cm. long, thick, sessile and clasping, with short rounded basal lobes: inflorescence elongated: sepals oblong, 3 mm. long: petals about 5 mm. long with spatulate blades and slender claw: pedicels in fruit 4–5 mm. long, spreading: pods ascending, 1–2 cm. long and about 1 mm. wide, somewhat torulose.

This species is perhaps most nearly related to *T. paniculatum*, but differs in the short pods and the broad basal leaves.

UTAH: Panguitch Lake, 1894, M. E. Jones, *6015e* (type in U. S. Nat. Herb.).

✓ **Lepidium Georginum** sp. nov.

Apparently biennial, cespitose from a slender taproot, 1–2 dm. high: stems hirsute with short spreading hairs: basal leaves 1–5 cm. long, deeply pinnately divided with ovate lobes; stem-leaves similar or the upper oblanceolate and entire; all more or less pubescent: inflorescence short: petals spatulate, slightly exceeding the sepals: pods pubescent, rounded oval, 4 mm. long, broadly winged above, forming at the apex two broadly ovate obtuse lobes, over 0.5 mm. long.

This species is in habit nearest *L. Wrightii* with which it has been confused; but it is less hairy and the pods are those of *L. dictyotum*.

UTAH: "Southern Utah," 1874, *C. C. Parry, 19* (type in herb. Columbia University); 1877, *E. Palmer, 40;* St. George, 1880, *M. E. Jones, 1614;* Milford, *1821* in part; 1894, *5110f.*

✓ **Thysanocarpus trichocarpus** sp. nov.

Annual, perfectly glabrous, except the fruit, 1–3 dm. high: stem terete, branched: lower leaves oblanceolate or oblong, sinuately dentate, thick and somewhat glaucous; uppermost leaves linear or linear-lanceolate, entire: racemes often 1 dm. long: petals slightly over 1 mm. long; blades broadly spatulate: pedicels in fruit about 5 mm. long, recurved: pod nearly orbicular, about 4 mm. wide, short-pubescent: wing-margins crenate or lobed, not fenestrate: style scarcely exceeding the wing-margin.

UTAH: Silver Reef, 1894, *M. E. Jones, 5163b*, in part (type in U. S. Nat. Herb.), *5149d* and *5139d.*

Trifolium lividum sp. nov.

Perennial, densely cespitose and tufted: branches of the caudex short and covered by the remnants of the leaf-bases and scarious stipules; free portion of the latter subulate-filiform: petioles 4–15 cm. long, slender, glabrous; leaflets linear-lanceolate or oblanceolate, very acute at both ends or cuspidate at the apex, 3–4 cm. long, glabrous above, sparingly appressed hairy beneath, green, entire-margined: peduncles 1–1.5 dm. high, sparingly appressed hairy: heads nearly 2 cm. in diameter; bracts linear-subulate to almost filiform, longer than the calyx-tube, glabrous, slightly if at all scarious-margined: calyx-tube 2.5–3 cm. long; teeth subulate-filiform, 4–5 mm. long: corolla about 12 mm. long, light purple with a darker keel.

This species is nearest to *T. dasyphyllum*, but is a larger, more glabrous and greener plant, and with much larger and narrower bracts. It grows at an altitude of about 3000 m.

COLORADO: Graymount, 1895, *P. A. Rydberg, 2442* (type in herb. N. Y. Bot. Garden); Alpine Tunnel, 1897, *C. L. Shear.*

Trifolium pedunculatum sp. nov.

Perennial, with a somewhat cespitose base: stems 2–4 dm. high, rather slender, striate, glabrous or with a few appressed hairs: stipules 2–3 cm. long, lanceolate, ½ or ⅔ of their length adnate to the petioles, denticulate: petioles 4–6 cm. long, slender; leaflets 3, oblanceolate to linear, acute, finely denticulate, 2–3.5 cm. long: peduncles 1 dm. or more long: heads 15–18 mm. in diameter, not bracteate: flowers subsessile, 10–12 mm. long, in fruit not reflexed: calyx-tube 2 mm. long, glabrous below, pubescent towards the throat; calyx-teeth subulate, the lower 3–3.5 mm. long: corolla purple.

This species is nearest to *T. longipes*, but differs in the smaller purple flowers and the calyx which is glabrous below.

IDAHO: Long Valley, 1895, *L. F. Henderson, 3096* (type in U. S. Nat. Herb.); near Sawtooth, 1896, *B. W. Evermann, 592.*

Lotus longebracteatus sp. nov.

Perennial, cespitose, decumbent: stems 2–3 dm. long, diffusely branched, grayish strigose: leaves thick, grayish strigose with a distinct rachis; leaflets 4, linear to oblong or of the lowest leaves obovate, 1–1.5 cm. long or the lower shorter: peduncles 4–5 cm. long, 1–2-flowered; bracts linear, about equalling the calyx: calyx strigose, its tube and teeth each about 4 mm. long; the latter subulate: corolla about 14 mm. long, strongly curved upwards, the banner much exceeding the wings and keel: pod linear, straight, 2.5–3 cm. long, pubescent.

This is in some respects intermediate between *L. rigidus* and *L. Wrightii*, differing from the former in the narrower leaflets, in the shorter peduncles, longer bracts and narrower calyx-teeth and from the latter in decumbent habit, leaves with a distinct rachis and elongated peduncles.

UTAH: "South Utah," 1877, *Dr. E. Palmer, 94* (type in U. S. Nat. Herb.).

Lupinus depressus sp. nov.

Perennial, cespitose: stems decumbent, 1–2 dm. long, appressed silvery silky pubescent: petioles slender, 5–7 cm. long, also silvery silky; leaflets about 7, oblanceolate, usually obtusish, 1.5–2 cm. long, densely appressed silvery canescent; stipules subulate: racemes short, slightly exceeding the leaves; bracts lanceolate, short, deciduous: flowers 8–9 mm. long: calyx long-villous; lips ovate-lanceolate; the lower about ⅓ longer than the upper: corolla light bluish-purple; banner glabrous, slightly shorter than the wings.

Being perhaps most nearly related to *L. minimus*, it differs from that in the decumbent or spreading leafy stem and more silky pubescence. It grows in gravel on dry mountain slopes, at an altitude of about 1750 m.

IDAHO: Divide between St. Joe and Clearwater River, 1895, *John B. Leiberg, 1201* (type in U. S. Nat. Herb.); Lo-Lo Trail, 1880, *S. Watson, 80.*

Lupinus Evermannii sp. nov.

Perennial and densely cespitose: the numerous stems about 1.5 dm. high, slender, erect or ascending, leafy, appressed hairy: petioles 2–4 cm. long, also appressed hairy; leaflets oblanceolate to linear-oblanceolate, 1–2.5 cm. long, densely canescent on both sides with long appressed hairs; stipules lanceolate, acuminate: raceme very short-peduncled, dense and short; bracts lanceolate, short, deciduous: flowers 6–7 mm. long; pedicels and calyx densely pubescent with spreading hairs; lips of the latter ovate-lanceolate, the lower about ⅓ longer than the upper: corolla purplish-blue; banner with a light spot, glabrous.

This species is nearest related to *L. holosericeus*, but the corolla is lighter and the pubescence of the calyx is spreading. It is also lower and more cespitose, resembling more *L. candicans* in habit, but has much smaller flowers.

IDAHO: Near Sawtooth, 1896, *B. W. Evermann, 533* (type in U. S. Nat. Herb.).

Lupinus Jonesii sp. nov.

Perennial, very stout: whole plant yellowish-green: stem over 1 mm. high, densely pubescent with two kinds of hairs, viz., a short pubescence and long spreading silky hairs; petioles about 5 cm. long, also pubescent with spreading hairs; leaflets 7–9, oblanceolate, densely appressed, yellowish hairy on both sides, 4–7 cm. long; stipules setaceous, deciduous: raceme long and dense, many-flowered; bracts subulate-filiform, much exceeding the buds; pedicels and calyx densely hairy with short spreading hairs: flowers about 16 mm. long: lips of calyx ovate-lanceolate; the lower about ⅓ longer than the upper: corolla white; the banner with a faint brownish spot; keel purple-tipped.

This species is nearest related to *L. leucophyllus*, but is less densely pubescent, the flowers are larger and in the type sheet whitish and the bracts are much longer. It grows at an altitude of about 4200 ft.

UTAH: Silver Reef, May 3, 1894, *Marcus E. Jones, 5143* (type in U. S. Nat. Herb.).

Lupinus adscendens sp. nov.

Perennial: stem 4–6 dm. high, appressed silky, leafy: petioles 5–10 cm. long, ascending, also appressed silky; leaflets about 7, linear-oblanceolate, 4–5 cm. long, acute, appressed silky on both sides but green; stipules subulate: racemes elongated, narrow; pedicels strongly ascending, rather long hairy: flowers about 12 mm. long: calyx grayish silky; the lower lip slightly longer than the upper: bract linear-subulate, much longer than the buds, almost equalling the calyx in length: corolla dark bluish-purple; the banner glabrous with a lighter spot.

This species is related to *L. laxiflorus*, but the calyx is not spurred and the bracts are much longer.

WYOMING: Headwaters of the Tongue River, 1898, *F. Tweedy, 129* (type in herb. N. Y. Bot. Garden); Head of Big Goose Creek, 1893, *F. Tweedy, 13*.

Lupinus argentinus sp. nov.

Perennial, densely appressed white-silky throughout: stem 4–6 dm. high: petioles 5–7 cm. long; stipules lanceolate-subulate; leaflets about 7, oblanceolate, densely silky on both sides, 3–5 cm. long, conduplicate and with strongly curved back: inflorescence rather short and dense; bracts ovate-lanceolate, short, deciduous: flowers about 1 cm. long: calyx and pedicels densely white-silky, spurred at the base; lower lip lanceolate, about one third longer than the upper: corolla bluish-purple; banner pubescent on the back, about as long as the wings: pods oblong, densely pubescent, about 3 cm. long and 5–6-seeded.

This species is nearest to *L. argophyllus*, but differs in the denser and whiter pubescence, the broader curved leaflets and the more pubescent banner. It grows at an altitude of 1200–2200 m.

UTAH: Near Reno, 1900, *S. G. Stokes* (type in herb. N. Y. Bot. Garden); Provo River, 1881, *M. E. Jones, 2169;* Salt Lake City, 1869, *S. Watson, 227.*

Lupinus comatus sp. nov.

Perennial, somewhat cespitose: stem about 3 dm. high, pubescent with long spreading silky hairs: petioles of the basal leaves about 1 dm. long, also pubescent with spreading hairs, leaflets narrowly oblanceolate, acute, 2.5–4 cm. long, green, pubescent on both sides; stem-leaves similar, but with shorter petioles; stipules linear lanceolate, long-acuminate: raceme short and dense, short-peduncled; bracts lanceolate-subulate, equalling or exceeding the buds; pedicels and calyx densely pubescent with spreading hairs; lips almost equal, ovate-lanceolate: flowers 8–10 mm. long: corolla bluish-purple, rarely white; banner slightly shorter than the broad wings.

The species is somewhat related to *L. laxiflorus* but the calyx is not spurred, the raceme short and dense, the flowers larger and the pubescence of the stem and petioles long and spreading.

COLORADO: Lake City, 1878, *F. N. Pease* (type in herb. Columbia University); Gunnison Co., 1895, *C. L. Pollard* (?) (U. S. Nat. Herb.).

Lupinus maculatus sp. nov.

Perennial, strict: stem 4–6 dm. high, finely appressed puberulent: petioles short, 2–4 cm. long, almost glabrous; leaflets 5–7, those of the lower leaves obovate-oblanceolate, mucronate; those of the upper oblanceolate and acute, sparingly appressed hairy beneath, glabrous above, 3–5 cm. long: inflorescence short-peduncled and dense; bracts ovate-lanceolate, acuminate, deciduous; the short pedicels and the calyx densely pubescent with short spreading hairs; lips of the calyx ovate-lanceolate, the lower slightly longer than the upper: flowers 10–12 mm. long; banner light purple with a dark spot, glabrous, much shorter than the white or purple-tinged wings; keel white with purple tip: pods oblong, densely pubescent, 2.5–3 cm. long, 4–5-seeded.

The type was labeled *Lupinus parviflorus*, to which it is somewhat related, but the raceme is much denser, the flowers larger, the corolla of a different color and with a very dark spot.

UTAH: P. V. Junction, Wasatch Mts., 1883, *M. E. Jones* (type in herb. N. Y. Bot. Garden and duplicates in U. S. Nat. Herb.); Woods Class, 1882, *M. E. Jones.*

Lupinus pulcherrimus sp. nov.

Perennial, more or less cespitose: stems 3–6 dm. high, sparingly appressed hairy, leafy: petioles 3–6 cm. long, also appressed hairy or glabrate; leaflets 7–9, linear-oblanceolate, acute, appressed silky on both sides, but green; stipules lanceolate, subulate: raceme more or less elongated and rather dense, short-peduncled; bracts lanceolate, short-acuminate, shorter than the buds, deciduous: pedicels and calyx grayish silky; lips of the latter lanceolate, the upper somewhat shorter: flower about 1 cm. long: corolla dark purple; banner with a light spot, pubescent on the back: pods broadly oblong, 3–3.5 cm. long, 5–6-seeded.

This species is also related to *L. laxiflorus*, but the raceme is denser, the calyx scarcely spurred, and the flowers are larger. It also resembles *L. pseudoparviflorus*, but in that species the leaves are glabrous above and the calyx also spurred. From *L. adscendens* it differs in the spreading flowers and the short bracts.

WYOMING: Battle, Continental Divide, 1901, *F. Tweedy, 4215* (type in herb. N. Y. Bot. Garden); Headwaters of Tongue River, 1898, *Tweedy, 130;* Big Horn Mountains, 1899, *Tweedy, 2365;* La Barge, Uintah County, 1894, *E. Stevenson, 158.*

MONTANA: Divide between McDonald and Comas Lakes, 1901, *F. K. Vreeland, 996;* Little Belt Pass, 1896, *P. A. Rydberg, 3318; J. H. Flodman, 620;* Baltic, 1900, *E. V. Wilcox, 58.*

Lupinus laxus sp. nov.

Perennial and somewhat cespitose: stem 4–6 dm. high, slender, sparingly appressed, silky: petioles 3–12 cm. long, appressed silky; leaflets 7–9, linear or linear-oblanceolate, 3–4 cm. long, green, but appressed silky on both sides; stipules subulate: racemes slender and lax; bracts lanceolate, short-acuminate, not longer than the buds: pedicels and calyx rather long, hairy: flowers about 8 mm. long: calyx not spurred; lips ovate, the upper slightly shorter: corolla light bluish-purple; banner broad, somewhat shorter than the wings.

This species is closely related to *L. laxiflorus*, but the flowers are smaller and lighter and the calyx is not spurred. It grows at an altitude of about 2000 m.

MONTANA: Forks of the Madison, 1897, *Rydberg & Bessey, 4442* (type in herb. N. Y. Bot. Garden), also *4443a*.

WYOMING: La Barge, Uintah Co., 1894, *E. Stevenson, 157* (somewhat more hairy than the type).

Lupinus leucanthus sp. nov.

Perennial, about 6 dm. high: stem minutely strigose, leafy: petioles about 6 cm. long, almost glabrous; leaflets 5–7, narrowly oblanceolate, 4–5 cm. long, acute or short-acuminate, glabrous above, sparingly appressed hairy beneath; stipules subulate: raceme lax; bracts lanceolate, acuminate, about equalling the pedicels, 6–8 mm. long: pedicels and calyx appressed short-hairy; lower lip of the latter linear-lanceolate, about ⅓ longer than the ovate upper one: corolla white with a brownish spot on the banner; the latter glabrous and almost equalling the wings.

This species is nearest related to *L. Scheuberae*, but differs in the larger white flowers and the longer upper lip of the calyx. The type sheet bears the name *Lupinus barbiger* Wats., but the plant is not at all related to that species.

UTAH: Springdale, 1894, *Marcus E. Jones, 5249e* (type in U. S. Nat. Herb.).

Pachylophus macroglottis sp. nov.

Acaulescent or nearly so: leaves 8–15 cm. long, tapering into a margined petiole; blades broadly oblanceolate, acute, sinuate-dentate, sparingly puberulent, and villous ciliate on the margins and the veins, very thin: hypanthium very long and slender, 12–14 cm. long, sparingly villous or nearly glabrous, gradually widening into a funnelform throat, which at the insertion of the sepals, petals and stamens, is about 1 cm. in diameter: sepals lanceolate, gradually long-acuminate, about 5 cm. long and much exceeding the broadly obcordate petals, which are about 3.5 cm.

long and fully as wide, very thin, at first white but turning pink in age: filaments about 2.5 cm. long: anthers versatile, 1.5 cm. long and 2 mm. wide: style exserted; lobes of the stigma about 5 mm. long: capsule with rather strong sinuately lobed ridges.

This species differs from *P. caespitosum* (Nutt.) Raimann in the villous ciliate leaves, the longer hypanthium which is much broader at the throat than in any of the other species, the longer sepals which much exceed the petals in length, and the less tubercled ridges of the pod. It grows in cañons at an altitude of 1500–2800 m.

COLORADO: Tributaries of Turkey Creek, 1900, *Rydberg & Vreeland, 5857* (type).

Pachylophus exiguus (A. Gray) Rydb. nom. nov.

Oenothera exigua A. Gray, Pl. Fendl. 1849.

This species was merged into *P. caespitosus* by Dr. Watson; but it is perfectly distinct. The plant is nearly always caulescent with a stem 0.5–2 dm. high, the leaves and hypanthium are villous as in the preceding species, but still more so, the hypanthium is fully as long, but less widened at the throat, and the angles of the pod with more prominent sinuately lobed crests than in *P. caespitosus.* This species is represented in the New York herbaria by the following specimens:

COLORADO: Rocky Ford, 1891, *C. S. Crandall;* Mesas near Pueblo, 1900, *Rydberg & Vreeland, 5858;* Rocky Ford, 1900, *G. Osterhout*, 2085.

NEW MEXICO: White Mountains, 1897, *E. O. Wooton, 659.*

ARIZONA: Walnut Cañon, 1898, *MacDougal, 341.*

✓ **Androsace puberulenta** sp. nov.

A puberulent rosulate annual: leaves oblanceolate, 1–3 cm. long, acute, entire or sinuately denticulate, densely puberulent: peduncles several, 3–10 cm. long: bracts narrowly lanceolate, 3–4 mm. long: pedicels 1–5 cm. long, spreading, densely puberulent: calyx 3–4 mm. long, cleft to the middle; tube glabrous, turbinate; lobes lanceolate, strongly keeled, densely puberulent, in fruit much exceeding the short capsule: corolla white, about equalling the calyx.

This species is in habit intermediate between *A. subumbellata* and *A. diffusa*, but differs from both in the densely puberulent pedicels and calyx-lobes. In both specimens mentioned the calyx-lobes are of the length and shape of the valves of the maturing capsules, while in *A. puberulenta* they are much longer. The range of the species extends from Manitoba and the Mackenzie River south to New Mexico. The type was collected in southern Colorado near Veta Pass, 1900, *Rydberg & Vreeland, 5772* (N. Y. Bot. Garden).

Gilia subacaulis sp. nov.

Apparently biennial with a slender taproot: stem less than 1 dm. high, almost leafless, diffusely branched, glandular-puberulent: leaves almost all basal, 1.5–3 cm. long, pinnatifid with triangular to oblong divisions, glandular-puberulent, or slightly white-villous when young: inflorescence open; pedicels 2–4 mm. long: calyx 2–2.5 mm. long, puberulent, scarious between the green ribs; lobes lanceolate, about half as long as the tube, acute: corolla 4–6 mm. long, funnelform, fully twice as long as the calyx, its tube distinctly exserted: stamens included: capsule rounded ovoid, acute, 4–5 mm. long.

This is related to *S. inconspicua*, but differs in the almost leafless stem, and the smaller corollas which have a comparatively longer tube. The following specimens belong here.

Wyoming: Point of Rocks, 1901, *Merrill & Wilcox, 607* (type in Herb. N. Y. Bot. Garden).

Utah: St. George, 1877, *Palmer, 328*; 1874, *Parry, 199*.

Colorado: Gunnison River, 1894.

Mertensia subpubescens sp. nov.

Mertensia Sibirica Rydb. Mem. N. Y. Bot. Gard. **1**: 335. 1901; mainly.

Perennial with a thick rootstock: stem simple, stout, 6–10 dm. high, glabrous throughout: lower leaves petioled, the upper sessile; blades broadly lanceolate, 5–10 cm. long, tapering at both ends, thin, glabrous or nearly so above, short-pubescent beneath and ciliate on the margin: inflorescence a rather many-flowered short panicle; pedicels slightly strigose: calyx-lobes oblong-linear, obtuse, ciliate on the margin, 2–2.5 mm. long, about ¼–⅓ as long as the corolla-tube: corolla about 12 mm. long; the tube only slightly longer than the limb: filaments broad and dilated, broader than the anthers and about half as long.

This is perhaps nearest related to *M. ciliata*, but is easiest distinguished by the pubescent lower surface of the leaves. It grows along streams at an altitude of 2000–2200 m. The following specimens from Montana belong here:

MONTANA: Spanish Basin, 1897, *Rydberg & Bessey, 4876* (type in herb. N. Y. Bot. Garden); near Indian Creek, *4872;* Bridger Mountains, *4875;* Mystic Lake, 1895, *C. L. Shear, 3076;* Deer Lodge County, 1901, *Mrs. Emma W. Scheuber, 42;* Basin, 1902, *Kelsey.*

Heliotropium spathulatum sp. nov.

Heliotropium curassavicum Hook. Fl. Bor. Am. **2**: 81. 1840. Not L.

? Heliotropium curassavicum obovatum DC. Prod. **9**: 538. 1845. Not *H. obovatum* D. Don.

A glabrous, more or less glaucous, fleshy perennial with ascending more or less branched stems, 3–5 dm. high: leaves spatulate, fleshy, indistinctly nerved, 2–5 cm. long, obtuse or rounded at the apex, tapering at the base and the lowermost petioled: inflorescence branched into 2–5 racemes; these often starting from one point at the end of the common peduncle: calyx about 3 mm. long, cleft to the middle; its lobes ovate-lanceolate, acute: corolla white or slightly tinged with blue, 6–8 mm. long; the limb of about the same width: nutlets 2.5–3 mm. long, scarcely rugose.

This is the common plant of the Rocky Mountain region that has been known as *H. curassavicum* L., but has much broader leaves, more than twice as large flowers and larger fruit than the cosmopolitan plant found on our eastern seaboard and in the southern states. It is probably the same as the plant collected by Douglas in the Blue Mountains of Oregon and briefly described in the places cited above. Hooker states that in the Blue Mountains were the only places where Douglas found *H. curassavicum.* In the Columbia herbarium there is a specimen, labelled: "California, *Douglas.*" If this specimen is one of those collected in the Blue Mountains and described by Hooker and DeCandolle, the synonyms cited above should be excluded; for the specimens evidently belong to the short-leaved and smaller-flowered form of *H. curassavicum* common on the Pacific coast and described by Willdenow under the name *H. chenopodioides.*

H. spathulatum is fairly common in meadows throughout the Rocky Mountain region and the great plains from Assiniboia and Washington to Iowa, New Mexico, Chihuahua and California. The type was collected at Great Falls, Montana, 1890, *R. S. Williams, 542* (in herb. N. Y. Bot. Garden).

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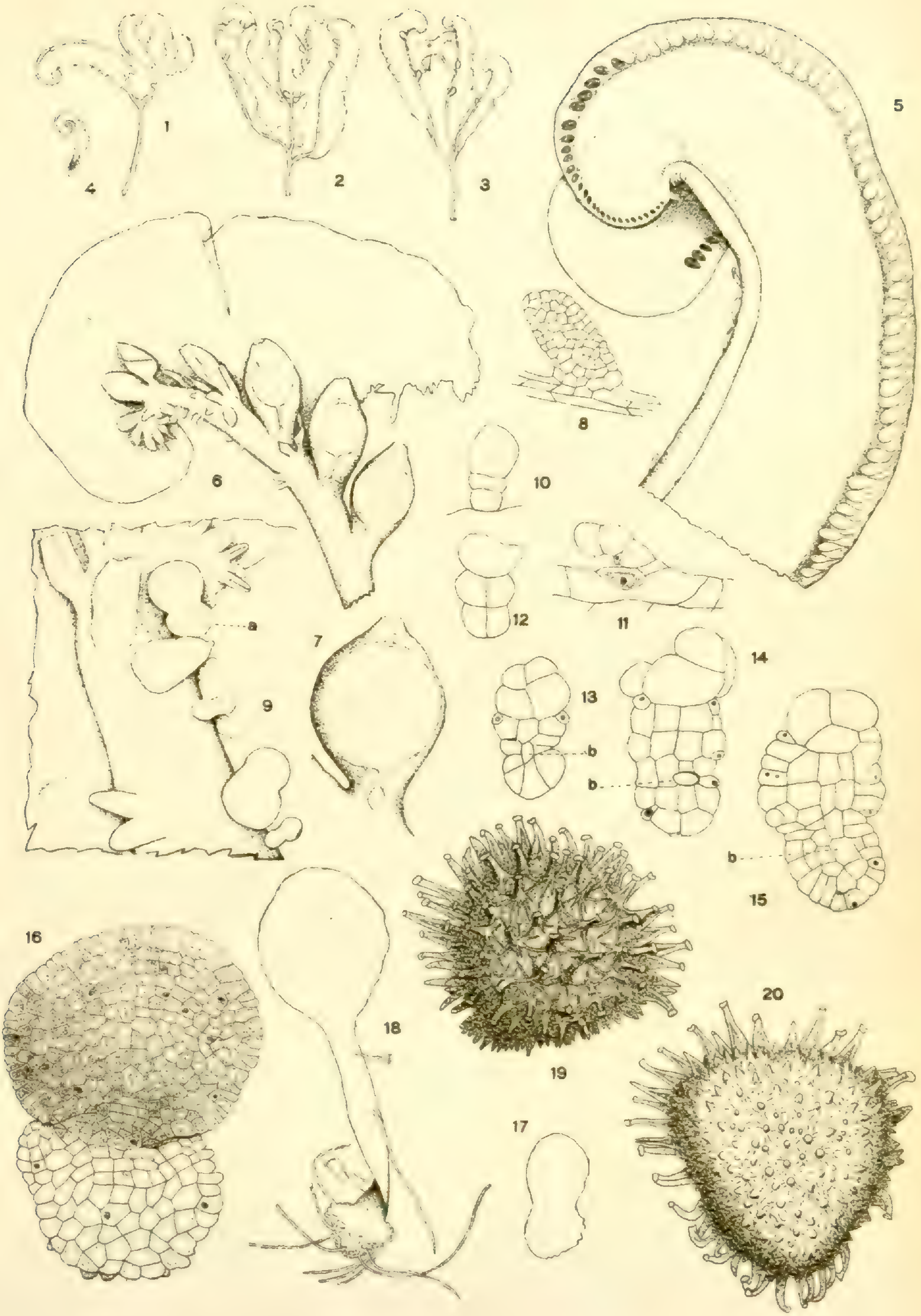
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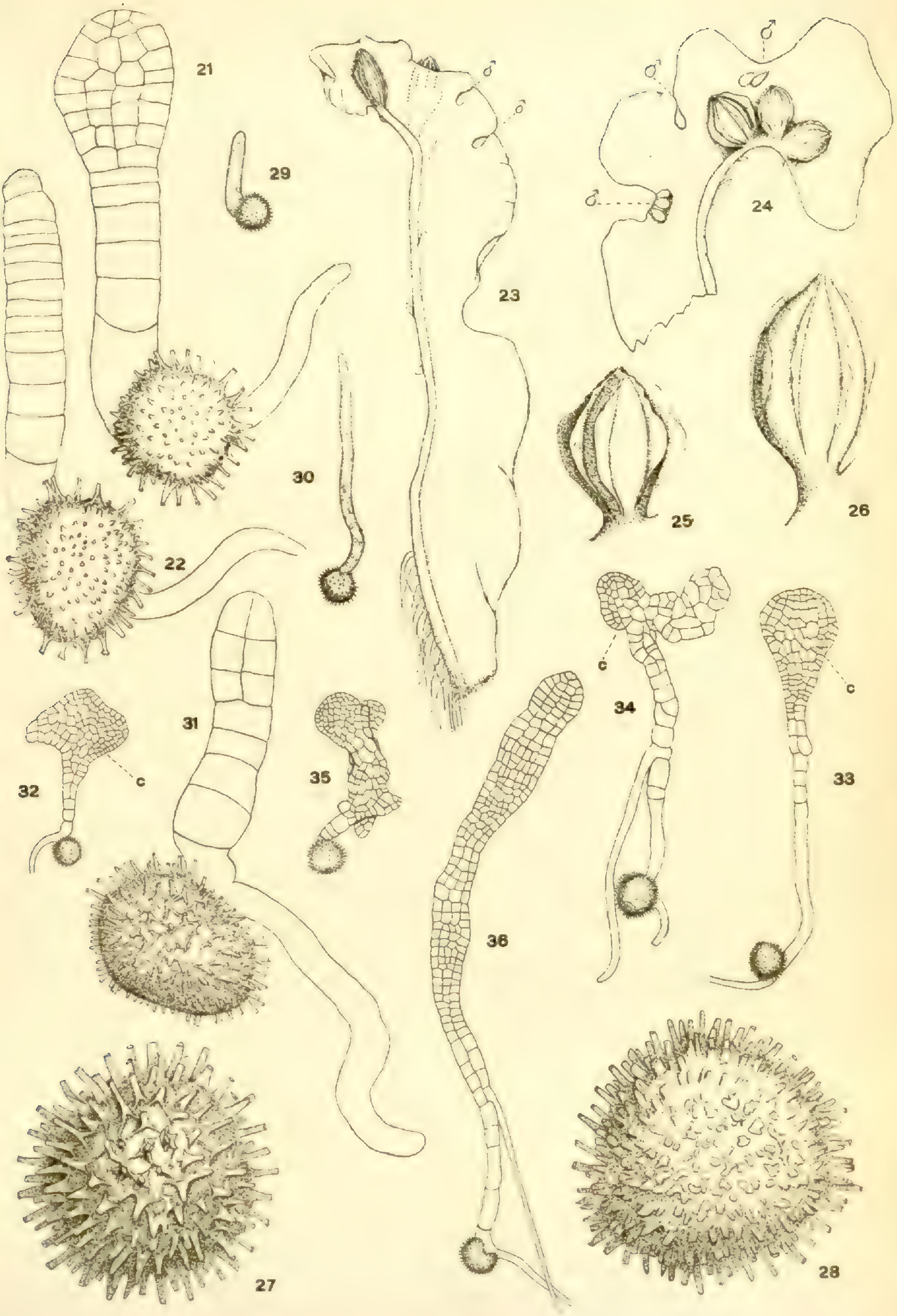
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21 and 22. RIELLA AMERICANA Howe & Underw.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

MAY, 1903

Some Generic Segregations

BY P. A. RYDBERG

(WITH PLATES 13 AND 14)

The concept of a genus may vary among botanists as well as among zoölogists. To some a genus is an aggregate of all forms of organisms which can be included within a certain artificial description or diagnosis; to others it is a natural group of closely related species or forms and may be modified, extended or limited as soon as these forms become better known. It is unnecessary to state that the former view nowadays has very few advocates, for nature was never made to follow the narrow concepts of man. A systematist who holds the second view, tries first to find what species are closely related, and when these are brought together, he tries to draw a diagnosis of the genus. The limitation of a genus depends naturally upon the personal views of the taxonomist. What is a single genus to one botanist may to another constitute half a dozen or more good genera, *i. e.*, groups of related species. It matters little how broad or narrow concepts we have of a genus, if only we are consistent and in the same family or tribe designate as genera equivalent natural groups of related species; *i. e.*, not making in one case the limits of a genus too large and in another too narrow.

I. An inconsistency of this kind exists, I think, in the usual treatments of the family Melanthaceae. *Chrosperma* and *Stenanthium*, *Melanthium* and *Veratrum*, are separated by rather trifling characters, while in *Zygadenus* are included species of no closer relationship. If we keep as distinct all of the first four genera,

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[The preceding number of the BULLETIN, Vol. 30, No. 4, for April, 1903 (30: 197–270, *pl. 11, 12*), was issued 24 Ap 1903.]

we must, if consistent, divide *Zygadenus* into at least three genera. Briefly these may be distinguished as follows :

Plant with a rootstock ; each petal and sepal with two glands.	*Zygadenus.*
Plant with a bulb; each petal and sepal with a single gland.	
Ovary wholly superior ; gland obovate or semi-orbicular.	*Toxicoscordion.*
Ovary partly inferior ; gland obcordate.	*Anticlea.*

ZYGADENUS Michx. Fl. Bor. Am. **1** : 213. 1803

This genus was established on a single species *Z. glaberrimus* and the generic name will go with it. This species differs from all that later have been included in the genus, in having a thick elongated rootstock instead of a bulb and two distinct round glands on each of the petals and sepals. As far as I know the genus consists of only one species.

Toxicoscordion gen. nov.

Glabrous, more or less poisonous perennials with narrow linear conduplicate leaves, yellowish racemose or paniculate flowers and membrane-coated bulbs. Flowers perfect (in one species described as polygamous, but as far as I know erroneously so). Petals and sepals bearing a single obovate or semiorbicular gland at or above the base of the blade, in most species more or less clawed. Ovary wholly superior. Stamens (except in one species) more or less adnate to the base of the petals and sepals ; anthers subreniform, confluently one-celled. Capsule 3-celled, 3-beaked, septicidal. Seeds numerous.

The first species known belonging to this group was published under the name *Amianthium Nuttallii* A. Gray ; but as this is somewhat aberrant from the general type of the genus, I have selected one of the most common species, *Zygadenus intermedius*, as the type. The following species belong here :

1. **T. intermedium** ; *Z. intermedius* Rydb.*
2. **T. venenosum** (S. Wats.) ; *Z. venenosus* S. Wats.
3. **T. gramineum** ; *Z. gramineus* Rydb.
4. **T. acutum** ; *Z. acutus* Rydb.
5. **T. falcatum** ; *Z. falcatus* Rydb.
6. **T. paniculatum** (Nutt.) ; *Helonias paniculata* Nutt.
7. **T. Nuttallii** (A. Gray) ; *Amianthium Nuttallii* A. Gray.

---

* For citations and synonyms, see Bull. Torrey Club, **27** : 534–538. 1900.

8. **T. Fremontii** (Torr.); *Anticlea Fremontii* Torr. Pac. R. R. Rep. **4**: 144. 1856; *Zygadenus Fremontii* Torr.; S. Wats. King's Exped. **5**: 343. 1871.

ANTICLEA Kunth.

This genus was established on *A. Sibirica* and *A. glauca* with *A. Mexicana* added as a doubtful species. *A. Sibirica*, the first one mentioned, must be regarded as the type. It differs somewhat from our American species, especially in the narrow somewhat recurved petals and sepals and the narrow glands, but these differences are rather unimportant and do not warrant any generic separation. The genus is characterized by a membranous coated bulb, linear glabrous leaves, greenish or yellowish-white flowers, withering persistent petals and sepals, which are adnate to the base of the ovary and bear a single obcordate gland; free stamens and a partly inferior ovary. The species are:

1. A. SIBIRICA (L.) Kunth, Enum. **4**: 191. 1843; *Melanthium Sibiricum* L. Sp. Pl. 339. 1753; *Zygadenus Sibiricus* Kunth, Enum. **4**: 192, as synonym.
2. **A. chlorantha** (Richards.); *Z. chloranthus* Richardson, Frankl. Journ. 736. 1821; *Z. commutatus* Schultes, Syst. **7**: 1560. 1830; *Z. glaucus* Nutt. Jour. Acad. Phila. II. **7**: 56. 1834; *Anticlea glauca* Kunth, Enum. **4**: 192. 1843.
3. **A. virescens** (H.B.K.); *Helonias virescens* H.B.K. Nov. Gen. & Sp. **1**: 267. 1816; *A. Mexicana* Kunth, Enum. **4**: 193. 1843; *Z. Mexicanus* Hemsl. Biol. Cent. Am. **3**: 382. 1885.
4. **A. elegans** (Pursh); *Z. elegans* Pursh, Fl. Am. Sept. 241. 1814.
5. **A. Coloradensis**; *Z. Coloradensis* Rydb. Bull. Torrey Club, **27**: 534. 1900.
6. **A. porrifolia** (Greene); *Z. porrifolius* Greene, Bull. Torrey Club, **8**: 123. 1881.

II. Another segregation needed, I have found in the genus *Rubus*. If *Dalibarda* is to be held distinct from that genus and *Duchesnea* from *Fragaria*, etc., certain species have to be removed from *Rubus* as now understood, as both in general habit and the structure of the fruit they are so unlike the rest of the species. The segregated genera would be distinguished as follows:

Styles club-shaped; stigmas slightly 2-lobed; receptacle flat; shrubs, unarmed, with shreddy bark and digitately ribbed maple-like leaves.
  Drupelets capped by hard hairy cushions; styles glabrous; erect shrubs. *Rubacer.*
  Drupelets without cushions; styles hairy; prostrate or reclining vines. *Oreobatus.*
Styles filiform, glabrous; stigmas usually capitate; receptacle hemispherical, conical or nipple-shaped; drupelets without cushions; leaves in most species pinnate and stem in most prickly. *Rubus.*

Rubacer gen. nov.

Unarmed shrubs with more or less shreddy bark, more or less glandular above. Leaves petioled, simple, digitately ribbed and lobed, with acute or acuminate lobes and cordate bases, resembling the leaves of certain maples. Flowers showy, in small panicles: sepals ovate with long slender acuminations: petals pink or white, oval or rounded: pistils numerous: receptacle flat or nearly so: drupelets numerous, capped with a dry, rather hard, finely and densely pubescent cushion with the club-shaped style attached under the margin.

The type is the first species cited below.

1. **Rubacer odoratum** (L.); *Rubus odoratus* L. Sp. Pl. 494. 1753.
2. **Rubacer parviflorum** (Nutt.); *Rubus parviflorus* Nutt. Genera **1**: 308. 1818; *Rubus Nutkanus* Moc.; Seringe, DC. Prodr. **2**: 566. 1825.
3. **Rubacer tomentosum**; *Rubus velutinus* Hook. & Arn. Bot. Beechey Voy. 140. 1841; Not Vest. 1823.
4. **Rubacer Columbianum** (Millsp.); *Rubus odoratus* var. *Columbianus* Millsp. Bull. W. Va. Agr. Exp. Sta. **2**: 355. 1892.

Oreobatus gen. nov.

Prostrate or reclining shrubby vines with light colored, shreddy bark. Leaves petioled, simple, maple- or gooseberry-like, digitately ribbed and lobed with rounded serrate lobes. Flowers showy, usually solitary: sepals ovate or ovate-lanceolate, acuminate or the tips foliaceous, in fruit erect: petals white, 1.5–3 cm. long, broadly obovate: stamens very numerous, hiding the fewer pistils: receptacle flat or nearly so: styles club-shaped, curved; stigma somewhat 2-lobed; young fruit apparently very pubescent, owing to the hairy styles: drupelets not very fleshy, without hairy cushions.

The first of the following two species is regarded as the type:

1. **O. deliciosus** (James); *Rubus deliciosus* James; Torr. Ann. Lyc. N. Y. **2**: 196. 1828.
2. **O. Neo-Mexicanus** (A. Gray); *Rubus Neo-Mexicanus* A. Gray, Pl. Wright. **2**: 55. 1853.

III. A similar inconsistency we find in the Loasaceae, where the genus *Mentzelia* as it is represented in United States is composed of at least four distinct groups deserving generic rank* with just as good right as several other recognized genera in the family.

The principal distinguishing characters are:

Placentae with horizontal lamellae between the seeds; these in 2 rows.
  Filaments 3-cleft at the apex, the middle tooth bearing the anthers, the lateral teeth cuspidate; seeds angled or with folds, not winged; annuals. *Bicuspidaria.*
  Filaments not cleft; seeds very flat, more or less winged; perennials. *Touterea.*
Placentae without lamellae; seeds usually prismatic.
  Placentae slender, filiform; ovules in one row, 10–40; seeds minutely muricate, not striate; filaments free or nearly so. *Acrolasia.*
  Placentae broad, band-like; ovules in 1–2 rows, few; seeds distinctly striate, often rugose; filaments at the base united with the petals into a ring. *Mentzelia.*

Bicuspidaria (S. Wats.) gen. nov.

Mentzelia § *Bicuspidaria* S. Wats. Proc. Am. Acad. **20**: 367. 1885.

Annuals with rather large flowers. Petals 5, free; stamens 80–130, dilated, 3-cleft at the apex, the middle tooth bearing the anthers; placentae with a vertical wing and horizontal lamellae between the ovules and seeds; these 15–40 in 2 rows on each placenta; capsule cylindric, inflated, sessile, thin-walled; seeds irregular, angled or with folds, not winged.

The first of the following species is taken as the type.

1. **B. tricuspis** (A. Gray); *Mentzelia tricuspis* A. Gray, Am. Nat. **9**: 271. 1875.
2. **B. involucrata** (S. Wats.); *Mentzelia involucrata* S. Wats. Proc. Am. Acad. **20**: 367. 1885.
3. **B. hirsutissima** (S. Wats.); *Mentzelia hirsutissima* S. Wats. Proc. Am. Acad. **12**: 252. 1877.

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* It may be that the other three sections of Urban and Gilg, viz., *Micromentzelia*, *Octopetaleia* and *Dendromentzelia* should also be treated as genera; but better knowledge is needed.

TOUTEREA Eaton & Wright, N. Am. Bot. 454. 1840

Bartonia Sims, Bot. Mag. *pl. 1487.* 1804. Not Muhl. 1801.
Torreya Eat. Man. Ed. 7. 560. 1836. Not Raf. 1818.
Hesperaster Cockerell, Torreya, **1**: 142. 1901.

This genus contains nearly all the large-flowered species included in *Mentzelia.* The outer filaments are more or less dilated; in most they are without anthers and in some as large as and resembling the petals. These species are often described as having ten petals. The genus *Touterea* was based on the first two species mentioned below; *Bartonia* Sims on *Bartonia decapetala* and the type of *Hesperaster* is the same. As far as I know, the following species belong here:

1. **T. decapetala** (Pursh); *Bartonia decapetala* Pursh, Bot. Mag. *pl. 1487.* 1812; *B. ornata* Pursh, Fl. Am. Sept. 327. 1814; *Touterea ornata* Eat. & Wright, N. Am. Bot. 454. 1840; *M. ornata* Torr. & Gray, Fl. N. Am. **1**: 534. 1840.
2. **T.** NUDA (Pursh) Eat. & Wright, N. Am. Bot. 454. 1840; *Bartonia nuda* Pursh, Fl. Am. Sept. 328. 1814; *M. nuda* Torr. & Gray, l. c.
3. **T. laevicaulis** (Dougl.); *Bartonia laevicaulis* Dougl.; Hook. Fl. Bor. Am. **1**: 221. 1833; *M. laevicaulis* Torr. & Gray, Fl. N. Am. **1**: 535. 1840.
4. **T. Brandegei** (S. Wats.); *M. Brandegei* S. Wats. Proc. Am. Acad. **20**: 367. 1885.
5. **T. parviflora** (Dougl.); *B. parviflora* Dougl.; Hook. Fl. Bor. Am. **1**: 221. 1833.
6. **T. pterosperma** (Eastw.); *M. pterosperma* Eastw. Proc. Cal. Acad. II. **6**: 290. 1896.
7. **T. stricta** Osterhout Mss.; *Hesperaster strictus* Osterhout, Bull. Torrey Club, **29**: 174. 1902.
8. **T. Rusbyi** (Wooton); *Mentzelia Rusbyi* Wooton, Bull. Torrey Club, **25**: 261. 1898.
9. **T. Wrightii** (A. Gray); *M. Wrightii* A. Gray, Pl. Fendl. 48. 1848.
10. **T. speciosa** Osterhout Mss.; *M. speciosa* Osterh. Bull. Torrey Club, **28**: 689. 1901; *M. aurea* Osterh. Bull. Torrey Club, **28**: 644. 1901. Not Nutt. 1818.

11. **T. densa** (Greene); *M. densa* Greene, Pittonia, **3**: 99. 1896.
12. **T. pumila** (Nutt.); *M. pumila* Nutt.; Torr. & Gray, Fl. N. Am. **1**: 535. 1840.
13. **T. chrysantha** (Engelm.); *M. chrysantha* Engelm.; Brand. Bull. U. S. Geol. Surv. Terr. **2**: 237. 1876; *M. lutea* Greene, Pittonia, **3**: 99. 1896.
14. **T. humilis** (A. Gray); *M. multiflora* var. *humilis* A. Gray, Pl. Wright. **1**: 74. 1852.
15. **T. multiflora** (Nutt.); *Bartonia multiflora* Nutt. Jour. Acad. Phila. II. **1**: 180. 1847.
16. **T. perennis** (Wooton); *M. perennis* Wooton, Bull. Torrey Club, **25**: 260. 1898.
17. T. MULTICAULIS Osterhout, Bull. Torrey Club, **30**: 236. 1903.

ACROLASIA Presl. Rel. Haenk. **2**: 39. 1831

Trachyphytum Nutt.; Torr. & Gray, Fl. N. Am. **1**: 533. 1840.

This genus was established on a Chilian species, *A. bartonioides* Presl, which has fewer ovules (12) and fewer stamens than its North American allies, but the structure of the ovary and seeds is the same. All the species are annuals and characterized by the long cylindric capsules, the filiform placentae and the muricate more or less prismatic seeds. Most of the species are small-flowered, with linear, lanceolate or ovate-oblong, laciniate, dentate or more rarely entire sessile leaves. The following North American species belong here:

1. **A. congesta** (Nutt.); *M. congesta* Nutt.; Torr. & Gray, Fl. N. Am. **1**: 534. 1840; *Trachyphytum congestum* Nutt.; Torr. & Gray, l. c.
2. **A. ctenophora**; *M. ctenophora* Rydb. Bull. Torrey Club, **28**: 33. 1901.
3. **A. Tweedyi**; *M. Tweedyi* Rydb. Mem. N. Y. Bot. Gard. **1**: 271. 1900.
4. **A. albicaulis** (Dougl.); *M. albicaulis* Dougl.; Hook. Fl. Bor. Am. **1**: 222. 1833; *Bartonia albicaulis* Hook. l. c.
5. **A. tenerrima**; *M. tenerrima* Rydb. Mem. N. Y. Bot. Gard. **1**: 271. 1900.

6. **A. integrifolia** (Wats.); *M. albicaulis* var. *integrifolia* S. Wats. King's Exp. **5**: 114. 1871; *M. dispersa* S. Wats. Proc. Am. Acad. **11**: 115. 1876.
7. **A. compacta** (A. Nelson); *M. compacta* A. Nels. Bull. Torrey Club, **25**: 275. 1898.
8. **A. gracilenta** (Torr. & Gray); *M. gracilenta* Torr. & Gray, Fl. N. Am. **1**: 534. 1840.
9. **A. affinis** (Greene); *M. affinis* Greene, Pittonia, **2**: 103. 1890.
10. **A. aurea** (Lindl.); *Bartonia aurea* Lindl. Bot. Reg. **22**: *pl. 1831.* 1836. Not *Mentzelia aurea* Nutt. 1818; *M. Lindleyi* Torr. & Gray, Fl. N. Am. **1**: 533. 1840.
11. **A. nitens** (Greene); *M. nitens* Greene, Fl. Francisc. 234. 1891.
12. **A. Veatchiana** (Kellogg); *M. Veatchiana* Kellogg, Proc. Cal. Acad. **2**: 99. 1863.
13. **A. pectinata** (Kellogg); *M. pectinata* Kellogg, Proc. Cal. Acad. **3**: 40. 1868.
14. **A. micrantha** (Torr. & Gray); *M. micrantha* Torr. & Gray, Fl. N. Am. **1**: 535. 1840.

IV. A fourth segregation is proposed in *Synthyris.* Professor Greene has included this genus in *Wulfenia* and he has been followed by many American botanists. *Wulfenia,* represented by European and Asiatic plants, has a 4-valved capsule, which is neither flattened nor emarginate at the apex, and a corolla with a long tube. All the American species have flattened capsules, which are 2-valved and obcordate at the apex. In this respect they agree perfectly with *Veronica.* The original *Synthyris* (*S. reniformis*) and a few related species have a corolla that is built exactly on the same plan as that of *Veronica,* and it is only the general habit that keeps them out of that genus. *S. alpina* and its relatives, on the contrary, have an altogether different corolla, cleft to near the base into two distinct lips. *S. rubra* and its allies have no corollas but agree otherwise both in general appearance and structure of the flower and fruit with *S. alpina.* It would however hardly be advisable to place them in different genera merely on account of the presence or absence of the corolla. The related genera are distinguished as follows:

Corolla scarcely 2-lipped; almost equally deeply 4-lobed.
  Corolla tubular-funnelform; capsule neither flattened nor obcordate at the apex, 4-valved.
    Leaves alternate but mostly basal. *Wulfenia.*
    Leaves opposite; stem leafy. *Leptandra.*
  Corolla rotate or short-campanulate; capsule flattened, obcordate, 2-valved.
    Leaves opposite or whorled; stem leafy. *Veronica.*
    Leaves alternate, but mostly basal; plant with a mostly naked scape. *Synthyris.*
Corolla, if present, deeply 2-lipped; upper lip entire, broad, arcuate; lower lip straight and deeply laciniate; leaves alternate but mostly basal; scape bracted. *Besseya.*

SYNTHYRIS Benth.; DC. Prodr. **10**: 454. 1846

This genus was based on *S. reniformis*. *S. rubra* was also included in the genus by the author, but he admits that it is a rather anomalous member, lacking the corolla. It is, however, more nearly related to *S. alpina*, which has a corolla of a different structure. The species belonging here are the following: *S. reniformis* (Dougl.) Benth., *S. major* (Hook.) Heller, *S. pinnatifida* S. Wats. and *S. laciniata* (Gray) Rydb. Whether *S. rotundifolia* A. Gray should also be included or should be made the type of a separate genus is a little doubtful. At present I am inclined to regard it as a *Synthyris*. So also *S. schizantha* Piper, with lacerate corolla-lobes, which species is still more aberrant.

Besseya gen. nov.

Low perennials with a thick rootstock. Basal leaves petioled; blades ovate or oblong, crenate; stem-leaves bract-like, alternate: inflorescence a bracted spike: calyx almost regularly 4-cleft to near the base or cleft to the base on the upper side and then 2–3-lobed: corolla 2-lipped, cleft to near the base, or lacking; upper lip, if present, entire, obovate or cuneate-obovate, concave; lower lip much shorter, often irregularly 2–3-cleft or laciniate: stamens 2, attached at the base of the corolla, or if this is absent on a small disk: capsule flattened, obcordate, 2-valved.

It is with pleasure that I dedicate this genus of western mountain plants to Professor Charles E. Bessey, of the University of Nebraska, my former teacher and the most prominent botanist of the region where these small plants grow.

The first species cited below is regarded as the type.

a. With corolla:

1. **B. alpina** (A. Gray); *Synthyris alpina* A. Gray, Am. Jour. Sci. II. **34**: 251. 1862.
2. **B. Bullii** (Eaton); *Gymnandra Bullii* Eat.; Eat. & Wr. N. Am. Bot. 259. 1840; *Synthyris Houghtoniana* Benth.; DC. Prodr. **10**: 454. 1846.
3. **B. plantaginea** (Benth.); *S. plantaginea* Benth.; DC. Prodr. **10**: 455. 1846.
4. **B. reflexa** (Eastw.); *S. reflexa* Eastw. Proc. Cal. Acad. III. **1**: 124. 1898.
5. **B. Ritteriana** (Eastw.); *S. Ritteriana* Eastw. l. c. 123.

b. Without corolla:

6. **B. rubra** (Dougl.); *Gymnandra rubra* Dougl.; Hook. Fl. Bor. Am. **2**: 103. 1838; *Synthyris rubra* Benth.; DC. Prodr. **10**: 455. 1846.
7. **B. gymnocarpa** (A. Nels.); *Wulfenia gymnocarpa* A. Nelson, Bull. Torrey Club, **25**: 282. 1898.
8. **B. Wyomingensis** (A. Nels.); *W. Wyomingensis* A. Nelson, l. c. 281.

NEW YORK BOTANICAL GARDEN.

Explanation of Plates

PLATE 13

FIG. 1. *Zygadenus glaberrimus* Michx. **a**, section of flower; **b**, sepal; **c**, petal; **d**, stamens; **e**, pistils.

FIG. 2. *Toxicoscordion intermedium* Rydb. **a**, **b**, etc., as above.

FIG. 3. *Anticlea elegans* (Pursh) Rydb. **a**, **b**, etc., as above.

FIG. 4. *Anticlea Sibirica* (L.) Kunth. **a**, **b**, etc., as above.

FIG. 5. *Rubus nigrobaccus* Bailey. **a**, section of receptacle; **b**, a young drupelet; **c**, stone.

FIG. 6. *Rubacer odoratum* (L.) Rydb. **a**, **b**, **c**, as in the preceding.

FIG. 7. *Oreobatus deliciosus* (James) Rydb. **a**, **b**, **c**, as in the preceding.

PLATE 14

FIG. 1. *Touterea decapetala* (Pursh) Rydb. **a**, section of the flower showing two of the petals and two of the similar staminodia; **b**, one of the petals; **c**, stamens; **d**, style; **e**, partial section of the capsule showing one placenta in front view and half of another in lateral view; **f**, winged seed.

FIG. 2. *Bicuspidaria tricuspis* (A. Gray) Rydb. **a**, section of flower; **b**, fruit; **c**, pistil; **d**, stamen with the two cusps; **e**, section of a part of the capsule, showing in

lateral view one half of two placentae with seeds, between them the horizontal lamellae and behind the vertical wings; between the latter are seen seeds on the third placenta; **f**, a seed.

FIG. 3. *Acrolasia albicaulis* (Dougl.) Rydb. **a**, section of flower; **b**, petal; **c**, stamens; **d**, pistil; **e**, capsule; **f**, longitudinal section of the same showing the narrow filiform placenta with seeds removed; **g**, a muricate prismatic seed.

FIG. 4. *Mentzelia oligosperma* Nutt. **a**, section of flower; **b**, stamen; **c**, pistil; **d**, section of a part of the capsule, showing the broad placenta with the seeds removed, except one; **e**, a striate seed.

FIG. 5. *Synthyris reniformis* (Dougl.) Benth. **a**, a flower; **b**, sepal; **c**, corolla laid open; **u**, upper lip; **l**, lower lip; **d**, pistil.

FIG. 6. *Besseya alpina* (A. Gray) Rydb. **a**, **b**, etc., as in the preceding.

Botanical Explorations in Georgia during the Summer of 1901.— I. Itinerary

By Roland M. Harper

My work on the flora of Georgia in 1901 was chiefly confined to the coastal plain, where more interesting botanical problems seem to be encountered than in any other part of the state. I entered the state at Savannah on the 4th of June, and on the morning of the same day went up to Millen, 78 miles northwest of Savannah, on the line between Burke and Screven counties, and about a mile east of the Ogeechee River, which here forms the northern boundary of Emanuel County. On the 5th I made two trips to the river (nos. 756–801),* exploring the swamps on both sides of it.

On the following day I went to the northern part of Bulloch County for a few weeks' stay at the home of a friend. Soon after crossing the Ogeechee River the pine-barrens (which are almost wanting in the vicinity of Millen), with their characteristic flora, made their appearance. At Graymont, in Emanuel County, where I left the railroad, I stopped to do a little collecting (nos. 803–820) before proceeding to my destination.

From the 7th to the 18th I was occupied in making the acquaintance of the plants of Bulloch County, collecting during this time several species of more than ordinary interest (nos. 821–916). The flora (making allowance for the difference in season) and the topography of northern Bulloch County were found quite similar to those of that part of Coffee County visited in September, 1900.

The floral areas of northern Bulloch County fall quite readily into the following five principal classes : sand-hills, dry, rather dry, and wet pine-barrens, and swamps (the last being perhaps capable of some subdivision). Each intergrades more or less with those next to it, but it is rare for any one species to be found in more than two of them. Some genera, however, have representatives in all. This is notably the case with *Rhynchospora*, which seems to be one of the largest genera of spermatophytes in this part of the state. The pine-barren ponds which are so characteristic of some parts of southwest Georgia are rare or wanting here.

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* These numbers refer to the plants collected.

Bulloch County is of interest historically as having been in all probability at one time the home of Mr. John Abbot, who has so skilfully portrayed a number of the interesting plants of Georgia in his "Natural History of the rarer Lepidopterous Insects of Georgia," published in 1797. Having examined this work a few weeks previously, I noticed on coming to Bulloch County the large number of plants growing in the vicinity which had been figured by Mr. Abbot, a larger proportion than I had ever seen elsewhere; and I collected several of them in order to throw more light on those which had never been definitely identified.

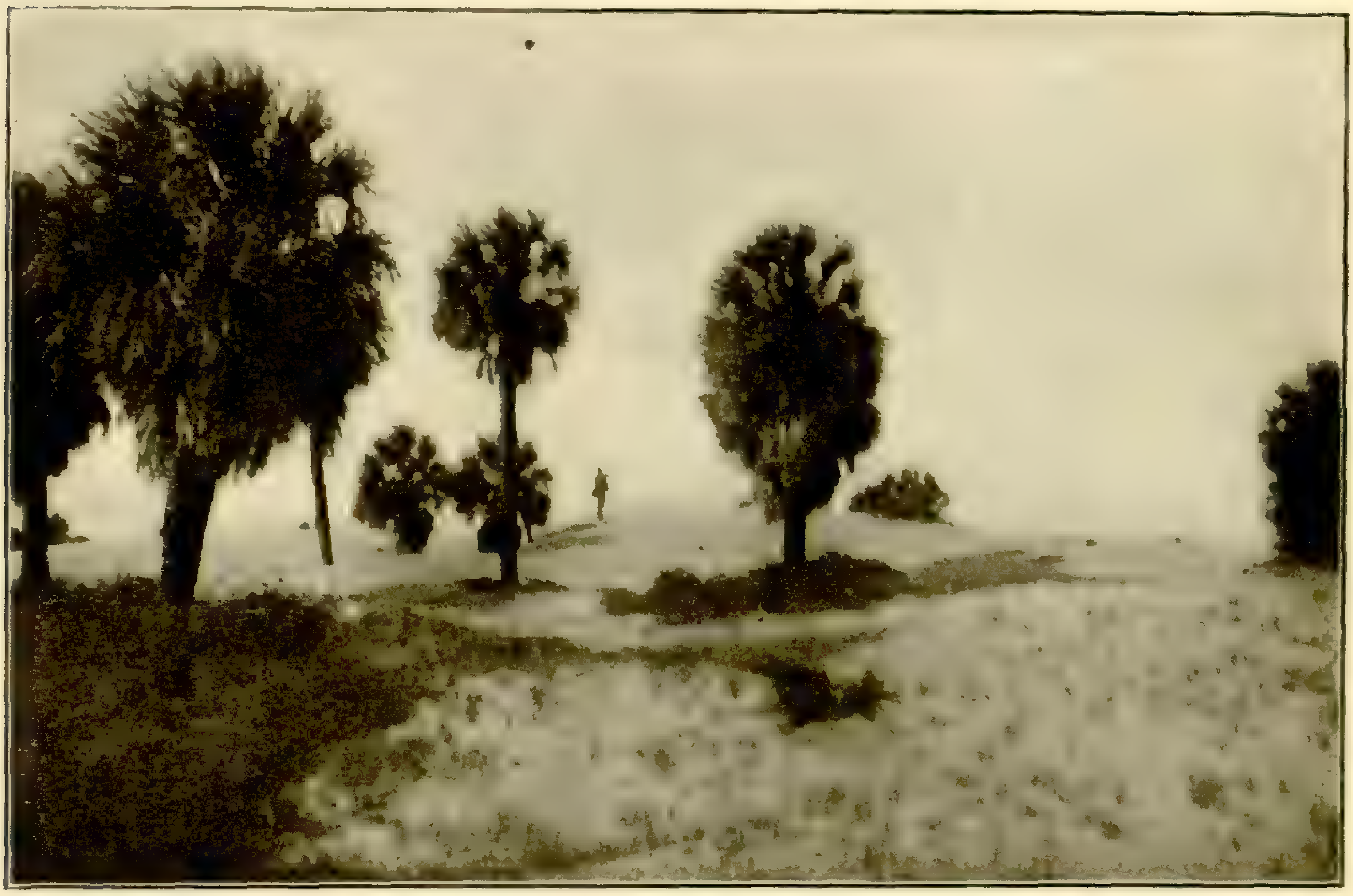

FIG. 1. Scene on the dunes of Tybee Island, showing *Sabal Palmetto*. June **21**.

On June 19 I went down to Savannah to spend a few days in that vicinity. On the 20th I collected (nos. 917–922) near Guyton, in Effingham County, thirty miles from Savannah, and on the 21st (nos. 923–933) on Tybee Island, at the mouth of the Savannah River. In Savannah I was joined by my brother, Otto T. Harper, who accompanied me most of the time during the rest of the summer, and assisted me with some of the work.

On the 22d I was back in Effingham County, and in the afternoon walked from Guyton to Springfield, the county seat, about six miles back from the railroad (nos. 934–938). The pine-barrens around Guyton differ from those farther inland in being more level and full of shrubs, mostly *Ilex glabra*, with some *Xolisma ferruginea* and two or three small species of *Quercus*. In the vicinity of Springfield, however, a marked difference is to be noted. About half way from Guyton to Springfield the country becomes rather hilly, and the pine-barrens disappear, giving way to shady deciduous woods sheltering many species of more northern distribution. This feature continues the rest of the way to Springfield and probably some distance beyond. Springfield is on the divide between the Ogeechee and Savannah rivers, and must be considerably higher than Guyton, which is near the Ogeechee and only about seventy-five feet above sea-level.

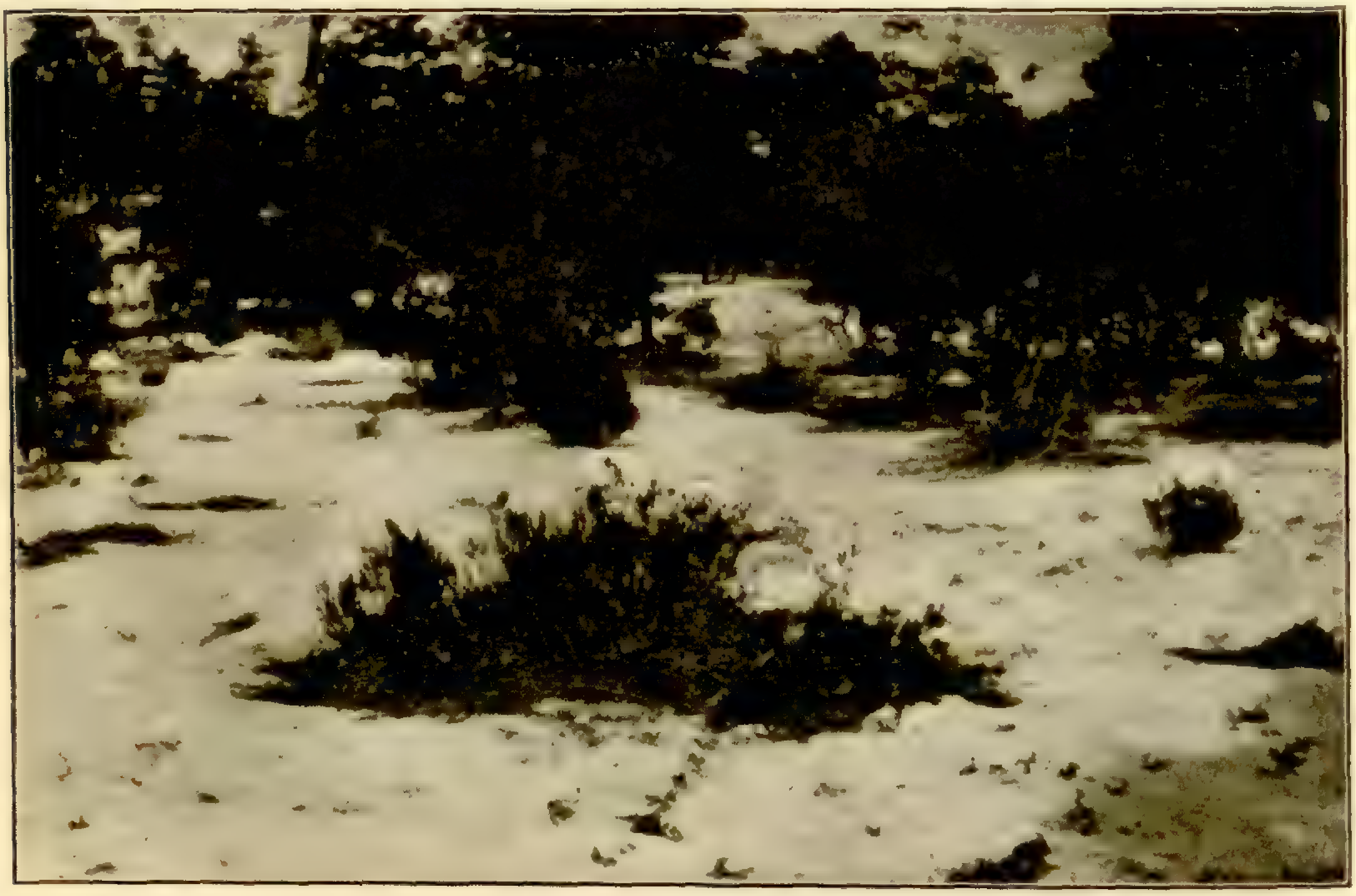

FIG. 2. Rosemary sand-hills, Emanuel County, Georgia. "Rosemary" (*Ceratiola ericoides*) in the foreground. June 28.

On June 24 I returned to Bulloch County, by way of Dover, Statesboro and Pulaski, collecting a few plants (nos. 939–943) at the latter place before starting across the country to my destination. For the next ten days I continued my studies of the flora of

Bulloch County, with most interesting results. During the first few days of my stay there I had heard some mention of a "Rosemary Church," several miles away, and on asking my friends if it did not derive its name from some plant, I was answered in the affirmative, and was given an interesting description of the place, but it was not until June 28 that I had an opportunity to visit it. Rosemary Church is situated on the left bank of Fifteen Mile Creek, in Emanuel County, among sand-hills of quite a different type from those seen elsewhere. The sand here is whiter than that of the ordinary sand-hills, and is said to be deeper, but as far as we know at present it is of the same Columbia formation. *Ceratiola ericoides*, the "rosemary," from which the place takes its name, is the most characteristic plant. The flora is not so rich as that of the ordinary sand-hills, but is composed mostly of different species, some of which will be mentioned in the latter part of this paper. The absence of grasses is a noteworthy feature. These rosemary sand-hills doubtless represent the extreme of xerophytic conditions in this region. My numbers 975–984 were secured on this trip to this rosemary sand-hills in Emanuel County, and numbers 944–974 and 985–988 were collected in Bulloch during the remainder of my stay there.

This eastern portion of the coastal plain of Georgia was quite familiar ground to Bartram, Michaux, Elliott, Baldwin, Beyrich and other early botanists, but has been considerably neglected since their time. After seeing many of the species of these authors in their type regions I found that I was able to understand them much better than before. This kind of study is much more satisfactory in many cases than any amount of examination of type specimens, too many of which are poorly preserved or accompanied by insufficient data.

On the morning of July 3 I left Bulloch County and drove over to Graymont on my way to the southwestern part of the state, stopping there again to collect a few plants (nos. 989–993). At Stillmore I also had a few hours to wait, and collected there numbers 994–996. During the afternoon I proceeded to Collins, in Tattnall County, where I remained until the next morning (nos. 997–1002). Collins seems to be in the same belt of flat country as Waycross, though it is considerably higher (235 feet above sea level). The rolling country appears again immediately west of Collins, however.

On the 4th I resumed my journey, and after traveling almost due west for 126 miles, mostly through rolling pine-barrens, stopped at Leslie, in Sumter County, where I had spent some time the previous year, though later in the season. My brother had preceded me there by several days. We made Leslie our headquarters until the latter part of August, in the meanwhile making several trips of greater or less extent to various places south and west of there. Within easy walking distance of Leslie, in the counties of Sumter, Lee and Dooly, I collected numbers 1003–1017, 1025–1082 and 1102–1126 in July and 1241–1247 in August. Numbers 1018–1024 and 1127–1146 were collected in and near Americus in July.

On July 17 we started on a journey to the Chattahoochee River, about seventy miles west, passing through the counties of Webster and Stewart, and into the terrane of the Cretaceous formations, corresponding to the "Central Prairie Region" of Alabama. The prairie feature seems to be lacking in Georgia, however, this region being more hilly than any other portion of the coastal plain of the state, some of the hills rising to a height of about 700 feet above sea-level. As far as I am aware, nothing has ever been published on the flora of this Cretaceous region of Georgia, beyond a few references by Bartram, who passed through the upper part of it in the summer of 1776, and described the natural features of the country in his "Travels," published several years later. Unfortunately a large proportion of this region is now under cultivation or has been otherwise tampered with, making the study of its natural floral conditions rather difficult, and in our short stay I did not have time to wander far from the highways of travel in order to study the more primitive conditions.

On the morning of the 18th I collected numbers 1083–1087 at Lumpkin and Union in Stewart County during the stops of our train. That afternoon we stopped at Omaha, the last station on the Georgia side of the river, and walked down the river a few miles (nos. 1088–1094). The most interesting plants were found immediately on the banks of the river, which are here about sixty feet high and very steep, and are covered with a dense growth of trees, of great variety and often of magnificent proportions, interspersed with cane-brakes of *Arundinaria gigantea* twenty or twenty-five feet tall. *Taxodium distichum* is here conspicuous by its absence, whether because of the steepness of the banks, or for some other reason, I do not know. These banks are so high that they are never overflowed, consequently there are no "bottom lands" along the river here.

At the time and place of our visit to the Chattahoochee River about ten feet of Cretaceous rocks were exposed at the base of the bank, rising perpendicularly from the water's edge, the rest of the bank being composed of the Columbia sands. Very few flowering plants grow on these rocks, which are difficult of access on account of their perpendicularity, but numerous springs issuing from the bank along the line of contact of the two formations supply moisture for many mosses and liverworts.

Early the next morning we visited an interesting pond (the only one seen in the Cretaceous region) in the woods south of Omaha (nos. 1095–1099). Later in the day we went up the left bank of the river a few miles (nos. 1100, 1101), then turned away from the river and walked east as far as Louvale. On the morning of the 20th we walked to Lumpkin, and from there took the next train back to Leslie. Between the river and Louvale I did not stop to do any collecting, but made many notes on the flora of the Cretaceous uplands. The flora of this region, at least in Stewart County, seems to be mostly a mixture of that of the Tertiary region nearer the coast and the metamorphic region on the north, with few if any endemic species. The abundance of *Arundinaria* is one peculiar feature, however, as in the corresponding portion of Alabama. The Cretaceous region of Georgia is doubtless analogous to the "tension zone" of New Jersey (described by Dr. Hollick *), which is also Cretaceous.

Our next trip outside of Sumter County was on the first three days of August, to Adams, in Lee County, midway between Americus and Albany. While traveling southward from Americus I was interested to see the same succession of topographic and floral zones that I was already familiar with between Americus and the Flint River to the eastward. These zones, which seem to correspond with certain geological formations, here run in a general northeasterly and southwesterly direction.

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* Am. Nat. 33: 1–14, 109–116. 1899.

On the train I met a former acquaintance, whose home was in Baker County, and after I had explained to him the object of my travels he mentioned that the cane (doubtless *Arundinaria gigantea*) had flowered in the vicinity of his home that spring, an occurrence which had never before been known to the oldest inhabitants. This corresponds with the observations of Dr. Mohr in Alabama, published on the preceding day.*

Adams is evidently in the same pine-barren zone as Leslie, but around Adams the Lafayette formation is mostly overlaid by the Columbia, which makes some difference in the flora. We remained in the vicinity until the 3d, during that time crossing Kinchafoonee Creek on the west and Muckalee on the east (nos. 1147–1162). On the east side of Muckalee Creek, some eight or ten miles southeast of Adams, are some interesting limesinks, a few of which were visited on the afternoon of the 2d. On the return trip to Leslie the next day, which was made partly on foot, I collected *Plantago sparsiflora* (no. 1163) near Smithville in Lee County and an apparently undescribed species of *Mesadenia* (no. 1164) a few miles south of Leslie in Sumter County.

The following week we started on a more extensive trip to the extreme southwestern part of the state, by way of Americus and Albany. Our first stop on this trip was at Camilla, in Mitchell County, on the 7th and 8th (nos. 1165–1170). The most interesting natural feature in the vicinity of Camilla is the "Slough," which is shown on most maps of Georgia, though I have never yet seen it mentioned otherwise. It is represented on the maps as a body of water about twenty miles long and one or two miles wide, approximately parallel to the Flint River in Mitchell and Decatur counties. But it is not a body of water at all, nor even a swamp. That portion of it which we explored, a mile or two west of Camilla, is simply a broad shallow depression about a mile wide and perhaps ten feet lower than the surrounding country. At the time of our visit there was considerable water in it as a result of recent rains (August being one of the wettest months in that part of the country), but it is said to be ordinarily quite dry for its whole

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*Contr. U. S. Nat. Herb. **6**: 103, 389. 1901.

length, except in a few holes which are deep enough to hold water throughout the year. The flora of the Slough is not very remarkable. The principal woody plants in it are medium-sized bushes of *Quercus Virginiana*, *Crataegus aestivalis*, and *Diospyros Virginiana*, with *Pinus palustris* in drier places. Among the herbaceous species in the Slough may be mentioned *Sporobolus Floridanus*, *Acerates Floridana*, *Breweria aquatica*, *Diodia teres*, *Chrysopsis graminifolia* and *Rudbeckia Mohrii*. This is very much the same kind of flora as is found around the mayhaw (*Crataegus aestivalis*) ponds of Sumter County. *Nama ovata*, conspicuous with its large bright blue flowers, was the only species found in the Slough which I had not seen elsewhere.

On the 8th we continued our journey as far as Thomasville. The next day was occupied with a trip to the type locality of *Nymphaea orbiculata*, about six miles northeast of the city (nos. 1171–1181). On the 10th we traveled west 21 miles, to Whigham, in Decatur County, in the midst of a topographically and botanically remarkable region. The surrounding country is quite hilly, much more so than that a few miles to the northward, and the forests are composed almost entirely of deciduous trees. Although less than sixty miles from the Gulf of Mexico, one standing in these deciduous forests could easily imagine himself among the mountains 250 miles farther north. Similar conditions prevail near Thomasville, though perhaps not in such marked degree; also at Tallahassee, Florida (which is about thirty miles from Whigham), according to the reports of geologists and botanists who have been there.*

Five or six miles north of Whigham these densely wooded hills terminate and the comparatively level pine-barrens of the Lower Oligocene or lime-sink region are again seen. About seven miles from Whigham is one of the most remarkable lime-sinks in the state. It is known to some geologists as Forest Falls, but the inhabitants of that region call it simply the "Lime Sink." There is a full-page illustration of it with description in Bulletin No. 5 of the Georgia Geological Survey. This lime-sink differs from all others which I have seen in its great depth (about ninety feet) and in containing a waterfall eighty feet high, making it one of the most beautiful natural features in South Georgia. I know of no other such waterfall in the entire coastal plain of the eastern United States. The side of the sink opposite the falls is not too steep to allow of an easy descent to the bottom, and we spent a couple of hours at this interesting spot on the morning of August 12 (nos. 1190–1194).

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* See Nash, Bull. Torrey Club, **23**: 96. 1896.

On leaving Forest Falls we walked southwestward toward Bainbridge about nine miles (nos. 1195–1201), to visit a pond which is also illustrated in the bulletin just mentioned. There it is called Fairview Lake, but we found "Open Pond" to be the name in current use in the vicinity. This pond is about half a mile in diameter, and takes its name from the fact that, unlike most of the ponds of the coastal plain, there is no vegetation showing above its surface except a few bushes near the shore. The water is unusually clear, and the shore is sandy, affording a habitat for several very interesting plants (nos. 1202–1206). In all these respects it resembles very much some of the ponds of New England.

Early the next morning we explored another pond about the size of Open Pond and two miles north of it, of which we had been told on the previous day. This latter is known as "Cane Water Pond," and is said to derive its name from the abundance in it of maiden-cane (*Panicum digitarioides*). It is very different from Open Pond, being surrounded by cypress (*Taxodium imbricarium*) swamps and filled with a luxuriant aquatic vegetation. Here we had the use of a boat, so were able to explore the pond somewhat thoroughly (nos. 1208–1213). Cane Water Pond is remarkable for containing a representative of each of our five North American genera of Nymphaeaceae, viz., *Cabomba, Brasenia, Nelumbo, Nymphaea* and *Castalia*. The *Brasenia* and *Nelumbo* are of course the same species as found in the northern states, but the other three genera are represented by different forms which will be mentioned later. The *Nelumbo* is quite rare, but the other four are abundant and their floating leaves together with those of *Limnanthemum aquaticum* serve to cover the surface of the pond very densely, leaving only two or three open spaces a few yards across. Another interesting feature of Cane Water Pond is the presence in it of several floating islands, composed principally of *Triadenum*

Virginicum, *Ludwigia sphaerocarpa*, *Ludwigiantha arcuata*, *Cephalanthus occidentalis*, and a small species of *Eleocharis*. The *Cephalanthus* is probably attached to the bottom, but the other species have no direct connection with the soil.

Around both Cane Water and Open Ponds, and all the way between them, the soil is of the Columbia sands, loose and dry, giving rise to a flora not unlike that of the sand-hills of southeast Georgia. In such situations numbers 1214 and 1215 were collected.

From Cane Water Pond we retraced our steps to Open Pond, followed the road from there toward Bainbridge about two miles, and then went back to Whigham by a different road. Soon after turning back toward Whigham we passed a limited area of very dry white sand, similar to that of the rosemary sand-hills of Emanuel County and containing a few of their characteristic species, which were not seen elsewhere in southwest Georgia (nos. 1216, 1217).

From Whigham I went alone on August 14 to Saffold, in the southwestern corner of Early County, on the Chattahoochee River, and collected along and near the river that afternoon and the next morning (nos. 1218–1232). The banks of the Chattahoochee at this point, about thirty miles from its confluence with the Flint and a hundred feet above sea level, are only about half as high as they are near Omaha, but still quite steep. As they are here subject to occasional overflow the flora is rather different from that farther up. *Rhus copallina*, *Aralia spinosa* and *Bumelia lycioides*, species which elsewhere are usually shrubs, here become truly arborescent. Specimens of *Aralia* with trunks six inches in diameter and twenty-five feet tall and of *Bumelia* eight inches thick and about fifty feet tall were observed.

There are several small lime-sinks between the station and the river, though this is very near the inland edge of the lime-sink region. A short distance north of the station is a rather remarkable feature for this part of the state, a steep rocky wooded hillside, sloping toward the river, with of course a rather peculiar flora. The outcropping rocks, which are very hard and siliceous, are clothed with mosses and lichens, and *Asplenium platyneuron* grows in their crevices, just as it does in the mountainous parts of the state. Among the flowering plants inhabiting this hillside are *Dioscorea, Hydrangea quercifolia, Cercis, Phaseolus polystachyus, Erythrina herbacea, Viola villosa, Yeatesia, Polymnia Uvedalia* and *Melanthera hastata.* Some fragments of the rock from this place have been identified by means of their fossils as Lower Oligocene.

About noon on the 15th I went back thirty miles over the same route I had come the day before, to West Bainbridge, where I collected numbers 1233–1238 in the Columbia sands along the Flint River, and during the afternoon I traveled forty miles northward on the Georgia Pine Railway through Miller and Early Counties to Arlington, in Calhoun County (nos. 1239, 1240). Arlington seems to be in the same pine-barren zone as Leslie, but on account of a heavy rain the next morning I was not able to study carefully the similarity of the floras. On the afternoon of the 16th I continued my journey to Albany, where I had a few hours to wait, so I went out across the Flint River to have a look at the flora and geological features, but did no collecting because this locality had been already pretty well explored by Dr. Chapman, Dr. Small and other botanists.

From Bainbridge, at the coastward edge of the lime-sink region, to Sumter County, at its inland edge, the flora of the banks of the Flint River does not seem to vary much, and all the species seen at Albany were the same as those already seen elsewhere. From Albany I went to Cordele, crossing the Flint River at still another place, where it forms the boundary between Lee and Worth Counties, and returned to Leslie the morning of August 17.

Ten days later I started for the metamorphic region, going by way of Richland and Columbus. At the latter place I crossed the Chattahoochee River to examine some of the geological features of the fall-line (the inland boundary of the coastal plain). On the morning of August 28 I left the coastal plain and went up to Woodbury, in Meriwether County, near the Flint River, 51 miles from Columbus, where I stopped two days (nos. 1249–1273).

The most noteworthy natural feature in the vicinity of Woodbury is the range of Pine Mountains, which extends approximately east and west through the counties of Harris, Meriwether, Talbot and Upson. These are the southernmost mountains in the eastern

United States, but they are rarely shown on maps and are very little known outside of their immediate vicinity. The only measurement of their altitude which I can find was made some years ago over G. M. & G. R. R. tunnel thirteen miles below Woodbury, and is 1,148 feet. This range passes within two or three miles of Woodbury, where the Flint River cuts through it in a narrow gap or gorge about 400 feet deep. Most of my collecting among the Pine Mountains was done in the vicinity of this gap, in Meriwether and Upson Counties. The mountains are very steep, especially in the vicinity of the river, where they rise abruptly from the water's edge with a slope of about 45°. The rock of which they are composed is a hard sandstone, which gives rise on disintegration to a very sandy soil, supporting a flora which is quite different from that of eastern Middle Georgia and resembles in many ways that of the coastal plain.

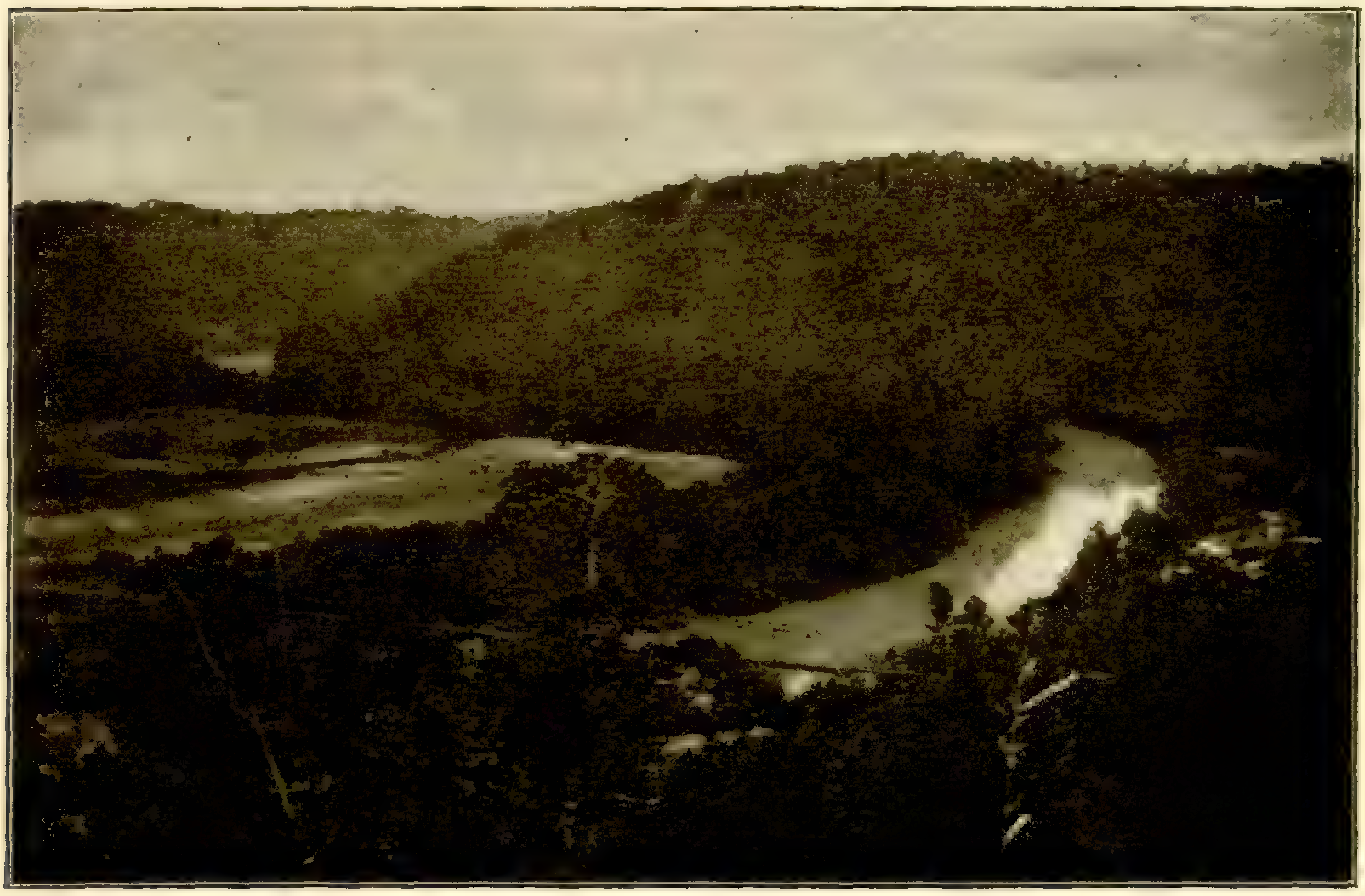

FIG. 3. Pine Mountains near Woodbury, showing gap of Flint River; looking southeastward from an isolated peak near the river. Aug. 29.

These mountains take their name from *Pinus palustris*, which is abundant all over them, often attaining as large dimensions as in the pine-barrens of South Georgia. Its occurrence here is not mentioned in even the most recent publications of the state agricultural department, and was therefore entirely unexpected. I heard of a few sawmills in operation among these mountains, but saw little evidence of their work. The flora of the dry southern slopes of the mountains is not unlike that of some of the dry pine-barrens 100 miles farther south, being characterized by such species as *Andropogon furcatus*, *Paspalum bifidum*, *Cyperus retrofractus*, *Yucca filamentosa*, *Agave Virginica*, *Quercus Catesbaei*, *Ceanothus Americanus*, *Crotalaria rotundifolia*, *Indigofera Caroliniana*, *Cracca Virginiana*, *Stylosanthes biflora*, *Vaccinium arboreum*, *Asclepias verticillata*, *Vernonia angustifolia* and *Chrysopsis graminifolia*. On the shaded northern slopes however many Alleghanian species are met with, such as *Dryopteris Noveboracensis*, *Uvularia perfoliata*, *Polygonatum biflorum*, *Trillium stylosum*, *Quercus rubra*, *Castanea dentata*, *Magnolia Fraseri*, *Heuchera Americana*, *Robinia Pseudacacia* and *Antennaria solitaria*. Along the banks of the river at the base of the mountains two species which are usually confined to the swamps of the coastal plain, *Nyssa uniflora* and *Cyrilla racemiflora*, are quite common at 650 feet altitude, the latter sometimes growing on rocky cliffs with *Kalmia latifolia*. The former extends up the river to Pike County.

Near Woodbury, at about 775 feet altitude, are some bogs with a flora much like that of similar places around Americus, containing such lowland species as *Lycopodium pinnatum*, *Cyperus Haspan*, *Eleocharis tuberculosa*, *Rhynchospora axillaris*, *Juncus trigonocarpus*, *Polygala cruciata*, *Rhexia Virginica*, *Eryngium virgatum*, *Gratiola pilosa* and others which will be mentioned later. On the 29th I went over into Pike County a few miles, and collected a few plants in a similar bog at about the same altitude, which contained besides some of the species just mentioned *Scleria trichopoda*, *Rhexia ciliosa*, *Cynoctonum sessilifolium*, *Viburnum nudum*, *Eupatorium verbenaefolium* and *E. rotundifolium*.

On the 30th I proceeded to Griffin, twenty-nine miles farther, noticing on the way that *Pinus palustris* extended up into Spalding County to within a few miles of Griffin. One species was collected in the woods near the Experiment Station that afternoon.

The next day I went by way of McDonough up to Atlanta, where I rejoined my brother. On September 3, we were at College Park, making collections in that vicinity, in the southern edge of Fulton County and adjacent portions of Campbell (nos. 1275–

1283). Two days later we went up to Dalton, from which point we made only one excursion before leaving the state, collecting numbers 1284–1292 on the Oostanaula Shale about two miles east of the city.

The number of days which I spent in Georgia in 1901 was the same as in the previous year, and although not so many specimens were collected, more was accomplished in other ways. My travels by rail within the state covered about 1,380 miles, and as about 98 per cent. of this distance was traversed in the daytime, I was able to make observations on the flora of nearly every mile traversed. I collected in twenty-four counties, and made notes on the flora of seventeen others. Over 100 photographs illustrating my observations were taken.

Among the noteworthy results of my trip may be mentioned the re-discovery of *Elliottia racemosa*,* the finding of inexhaustible quantities of *Isoetes* in the coastal plain of Georgia, where none had been known to exist before, and the exploration of the sandhills of southeast Georgia, the Cretaceous region, the Slough, Forest Falls, the ponds of Decatur County, and the Pine Mountains.

Dr. Mohr's "Plant Life of Alabama," which appeared during the summer, was a great help to me in several ways, giving me an opportunity to compare the floral conditions in Georgia with those of the corresponding portions of Alabama; and it was a source of considerable satisfaction to note how nearly his treatment coincided with that which I had already planned for Georgia.

Some of the undescribed or otherwise noteworthy plants collected on this trip will be discussed in the concluding portion of this paper.

College Point, N. Y.

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*See Plant World, **5**: 87–90. *pl. 12.* My 1902; also Sargent, Silva N. Am. **14**: 31. 1902.

The Polyporaceae of North America.—IV. The Genus Elfvingia

By William Alphonso Murrill

The mycological field of Europe is small as compared with that of America. The European mycologist has in general a small country with limited variation in altitude, geological formation and season, as well as a limited number of host plants, few of which are readily attacked by wood-loving fungi ; hence it is possible to know more minutely the forms that do occur and to segregate varieties according to host, position and other details of which little note has yet been taken in America. The confusion of forms in Europe is largely due to former difficulties in travel, limited means, lack of interest in the work of others and lack of generalization, a condition of affairs accounted for to some extent by difference in language and the antipathy common among neighbors. Upon receiving an exotic plant, be it from Guinea or Greenland, the mycologist of limited outlook makes a heroic effort to correlate it with some species growing in his immediate vicinity and, failing to do this, either loses interest altogether in the matter or half-heartedly looks up a name for it in some foreign flora. To send American fungi abroad for determination is usually to be either disappointed or deceived. To many European botanists, Kew is a very foreign country and America is off the map.

One should not be surprised to find, therefore, that many American plants are parading under false names and that many are entirely new to the botanical public ; and what is true of species is likewise true of genera ; the old molds must be recast and several new ones added to accommodate these large additions. For our northern forms, the work of recasting has been largely done by Dr. P. A. Karsten, of Finland, who has to deal with a local flora very similar to our own in its lines of cleavage, although the abundance of species present in our latitude is unknown in Finland. The basis of this similarity between North American and North European and Russian genera is found in the fact that these countries have been practically continuous so far as distribution is concerned, whereas the continents of the southern hemisphere have very probably been for ages widely separated by impassable barriers of open sea. The principles above enunciated are well illustrated in the genus *Elfvingia* of Karsten, a discussion of which follows.

ELFVINGIA Karsten, Findlands Basidsv. 333. 1889

This genus was described by Karsten as follows:

> "Hatten beklädd med en spröd, skorpartad hud, glatt. Cystiderna föga anmärkningsvärda. Basiderna n. klotrunda, 4-sporiga. Sporerna äggrunda, vårtfulla, gulbrunaktiga."

The only representative of the genus in Finland, according to Karsten, is *Elfvingia applanata* (Pers.) Karst., a species first described as *Boletus Lipsiensis* by Batsch (Elench. Fung. **2**: 183–185. *pl. 25. Fig. 130. a, b.* 1786), then as *Boletus applanatus* by Persoon (Obs. Myc. **2**: 2. 1799), and later as *Polyporus merismoides* by Corda (Sturm, Deutschl. Flora, **3**: 139–142. *pl. 63.* 1837). Its close relationship to *P. fomentarius* L. may be judged from the fact that Persoon in his Synopsis treats it as a variety of the latter plant, although he had described it as a distinct species only two years before. In the present treatment of the genus *Elfvingia*, **E. Lipsiensis** (Batsch) will not appear, since it does not occur in America, its place being taken by *E. megaloma* (Lév.).

Synopsis of the North American Species

1. Context ferruginous, spores hyaline, pileus usually ungulate. 2.
Context darker, fulvous to chocolate-brown, spores yellowish-brown, pileus usually applanate. 3.

2. Pileus exactly ungulate, pores 3 to a mm., growing in temperate regions south to Carolina. 1. *E. fomentaria.*
Pileus compressed ungulate, pores 5 to a mm., growing in tropical America and the gulf states. 2. *E. fasciata.*

3. Hymenophore annual, persisting above later growths; pileus reniform, margin thin, spores dark brown, roughly echinulate, $8–9 \times 7 \mu$. 3. *E. reniformis.*
Hymenophore truly perennial, tubes stratified, spores smooth or nearly so. 4.

4. Crust white, becoming brown, not separating, spores smooth, $8–9 \times 5 \mu$, growing in temperate regions. 4. *E. megaloma.*
Crust brown, context floccose, softer, spores smooth or slightly echinulate, growing in tropical America. 5.

5. Pileus thick, crust smooth and very hard, hymenium plane, margin truncate, very smooth, often laccate, context very thin, spores smooth or slightly verrucose, $7–9 \times 5–6 \mu$. 5. *E. tornata.*
Pileus thin, crust radially wrinkled, thinner, hymenium concave, margin undulate, never laccate, spores smooth, $8 \times 5 \mu$. 6. *E. Lionetii.*

1. **Elfvingia fomentaria** (L.)

Boletus fomentarius L. Sp. Pl. 1176. 1753.

Boletus ungulatus Bull. Herb. France, *pl. 491. fig. 2, C. D. E.*

Polyporus fomentarius Fr. Syst. **1**: 374. 1821.

Fomes fomentarius Gill. Champ. Fr. **1**: 686. 1878; Icon. 467.

See also Sowerby, Engl. Fungi, *pl. 133*, and Schaeffer, *pl. 137*.

This fungus is widely distributed on birch and beech in the temperate regions of Europe and North America. It varies little in shape and appearance in the north, though very small forms occur in high latitudes. One of these brought from the Isle à la Crosse by Dr. Richardson was described by Berkeley as var. *excavatus* (Ann. Nat. Hist. **3**: 387. 1839). The type specimens at Kew agree in all respects with *P. fomentarius* as it grows in the Adirondack Mountains and in Sweden. A more southern form, larger, thicker, more uniform and ashy in color, is known in Europe as *Polyporus Inzengae* De Not., but as this does not occur in North America it need not be discussed at present. When fruit-bodies of *P. fomentarius* become old and indurated and lose their outer pellicle the horny crust takes a high ivory-black polish and is very different from the usual covering of the plant. It is this form that has frequently been mistaken for *P. nigricans* Fr. At Kew, *P. igniarius* and *P. applanatus* have been variously confused with *P. fomentarius*.

In addition to the usual European and American exsiccati, all of which contain this species, material has been examined from Germany (Magnus), Sweden (Murrill), France (Patouillard), Finland (Karsten), Italy (Bresadola), Scotland (Klotsch), Canada (Macoun), Maine (Ricker), New Hampshire (Miss Minns), Massachusetts (Mrs. French), Wisconsin (Baker), New York (Underwood), Connecticut (Miss White), and most of the other states south to North Carolina and west to California.

2. **Elfvingia fasciata** (Sw.)

Boletus fasciatus Sw. Prod. 149. 1788; Fl. Ind. Occ. **3**: 1921. 1806.

Polyporus fasciatus Fr. Syst. **1**: 373. 1821.

Polyporus sclerodermeus Lév. Ann. Sc. Nat. Bot. III. **5**: 129. 1846.

Polyporus marmoratus Berk. & Curt. Proc. Am. Acad. **4**: 122. 1858.

Fomes fasciatus Cooke, Grevillea, **14**: 21. 1885.

Specimens examined: Ellis & Everhart, N. A. Fungi, no. 1702; Florida (Martin, Calkins, Rolfs, Lloyd, Rau), Louisiana (Langlois), Alabama (Underwood, Earle, Baker), Texas (Egeling), Jamaica (Earle).

This plant is fairly abundant in tropical America, being known from nearly all localities that have been explored. Earle found it at three different points in Jamaica growing on *Cedrela* and cocoanut logs. It replaces *E. fomentaria* in the south, but cannot be confused with it as some have supposed.

3. **Elfvingia reniformis** (Morg.)

Polyporus reniformis Morg. Jour. Cincinnati Soc. Nat. Hist. **8**: 103. 1885.

Fomes reniformis Sacc. Syll. **6**: 187. 1888.

Collections examined: Ohio (Morgan), Kentucky (Miss Price), Indiana (Underwood), Virginia (Murrill, Mrs. Murrill), North Carolina (Memminger), Alabama (Underwood, Earle), Louisiana (Langlois).

When first sent to Kew this plant was determined as *P. applanatus* Pers., a closely allied European species. Later it was placed by Cooke under *P. incrassatus* Berk., a plant indigenous to Australia! It may be said, however, that the specimens now at Kew are not fairly representative even of the form and much less of the habit of Morgan's species. The following extract from one of D. L. James' letters written in 1882 refers to the peculiarities of *P. reniformis*: "I am rather surprised at my fungus turning out to be *P. applanatus.* It grows at the foot of old oak stumps and trees and seems to be an annual, the previous year's growth being found distinct and above the new growth in a decayed condition. The pileus does not harden as in *P. applanatus.*" By *P. applanatus* is, of course, meant our ordinary species, *P. megaloma* Lév. "Again, the hymenial surface instead of being flat, is curved upwards in every case, this feature being well shown in the specimen sent.

However, your experience I shall certainly hold above my ignorance."

During a recent trip through the southwestern part of Virginia, I found this fungus very common on stumps and decaying trunks of oak. In every case the fruit-bodies of previous years were dead, with the later growths below. I have specimens taken from a white oak trunk on which I saw the first fruit-bodies two years ago and some of these have three layers, some two and some one, only the last year's growth in each case being alive. This corroborates James' testimony to his belief that the fruit-bodies are annual. During the same trip, I collected a few specimens of *E. megaloma* on its usual hosts and noted with interest that the two species are as distinct in Virginia as they are farther north. Facts thus far collected indicate that *E. reniformis* is a southern form and confined to a much more restricted area than *E. megaloma*, while within this area it is often abundant and quite destructive to the oak, its favorite host.

4. **Elfvingia megaloma** (Lév.)

Polyporus megaloma Lév. Ann. Sc. Nat. Bot. III. **5**: 128. 1846.

Polyporus leucophaeus Mont. Syll. Crypt. 157. 1856.

Fomes megaloma Cooke, Grevillea, **14**: 18. 1885.

Ganoderma leucophaeum Pat. Bull. Soc. Myc. **5**: 73. 1889.

Specimens have been examined from New York (Shear, Murrill), Canada (Anderson), Pennsylvania (Ellis), Virginia (Miss V. W. Murrill, Murrill), and nearly all the other states west to California and south to Georgia. The plant occurs abundantly on dead or dying wood of oak, sweet gum, poplar and other deciduous trees. In the popular mind it is associated with etching because its hymenium changes to a darker color when bruised. Owing to the close resemblance to *P. applanatus* Pers. in habit and appearance, it has been generally known under that name among American mycologists. The correct name for it, however, appears to be that assigned to it by Léveillé in 1846 on receiving specimens collected by Ménand in New York. In connection with his description, he notes that it is near *P. applanatus* in form, consistency and volume, but differs essentially in the color of the cap and the pores and especially in the presence of a wide sterile border circumscribing the tubes below.

5. **Elfvingia tornata** (Pers.)

Polyporus tornatus Pers.; Gaud. Voy. Freyc. Bot. 173. 1826.
Polyporus australis Fr. Elench. 108. 1828.
Fomes australis Cooke, Grevillea, **14**: 18. 1885.
Ganoderma australe Pat. Bull. Soc. Myc. **5**: 71. 1889.
Scindalma tornatum Kuntze, Rev. Gen. **3**: 517. 1898.

Described from islands in the Pacific ocean and apparently of general occurrence throughout tropical America, since most of the collections from that region contain specimens of it. A large plant was collected last year by Percy Wilson in Porto Rico, and Earle on his recent visit to Jamaica found it at three different stations; at Port Maria on a dead limb of a leguminous tree, at Hope Gardens on a dead deciduous trunk and at Port Antonio on the stump of a hog plum and the fallen trunk of a cocoanut palm.

6. **Elfvingia Lionetii** (Rolland)

Ganoderma Lionetii Rolland, Bull. Soc. Myc. **17**: 180. *pl. 8.* 1901.

This plant was collected by M. Lionnet on trunks in the isthmus of Panama. It is closely allied to *E. tornata*, but is thinner with a thinner crust, which is usually profoundly wrinkled from the center outward. The context is floccose, elastic, brownish-rufous, and the spores ovoid, smooth, fulvous, 8 x 5 μ. Several specimens are in the New York Botanical Garden collected by C. L. Smith in Nicaragua.

NEW YORK CITY.

The Desert Flora of Phoenix, Arizona

By Richard E. Kunzé

The Sonoran flora of the Salt River Valley of Arizona, between Phoenix and Tempe, during December, January and February of each year presents such a strong contrast to that of the north, that a description of it as seen after the autumn or winter rains may not be out of place. This valley has an altitude of 1,100 feet above the sea, is about sixty miles long and has a width of nearly twenty miles. It once was an inland sea, and the red sand buttes, largely composed of conglomerate rock, plainly show the effect of erosion on every side. From east to west this valley is traversed by the Salt and Gila rivers. To the north it is bounded by the Phoenix mountains, and to the south by the Maricopa mountains, running east and west, and the Estrella mountains, westward. In various places sandstone buttes jut out from the mountain into the valley.

At the beginning of December, when the deciduous shrubs and trees of the bottoms defoliate, those of the deserts adjoining put on a verdure which lasts until the succeeding spring. The cactus desert proper extends only from two to four miles on every side of these mountains, changing then into the sagebrush desert, which in turn is bounded by the bottom lands of the rivers. The striking feature of the Sonoran flora is the giant cereus or "saguara" of the Mexicans, *Cereus giganteus*, reaching here a height of forty feet and over. In April and May this *Cereus giganteus* has large white flowers, which appear at the end of candelabrum-like branches, and arranged in crescentic rows encircling the stem, to the number of fifty and seventy-five on a single stem. In July the scarlet fruit appear, which are luscious and are gathered by Indians and Mexicans to be made into jelly and sweetmeats, or eaten raw. A wine is obtained from it by fermentation.

Echinocactus Wislizeni or fishhook cactus, is here found in the crevices of the rock. It more largely affects the mountain sides or rocky "arroyos," which carry the waters to the bottoms. A few are scattered among the sagebrush, *Artemisia tridentata* and another species, growing in a sandy loam ; these cacti sometimes attain a barrel-shape, weighing from 150 to 200 pounds each. Such individuals, however, are rare. The flesh of this cactus is by Mexicans made into candy, much like the sugar-coated calamus or sweet flag. Parched travelers of our deserts often cut open large plants of *E. Wislizeni* to suck the moist pulp, when waterholes cannot be reached or found. The yellow flowers appear in May and often again in September, for a second time, followed by a yellow fruit, dry and insipid.

Another species, *Echinocactus Emoryi*, or barrel cactus, is sparingly found in this valley, and occurs in preference on sandy sagebrush desert. The large central spines of *E. Emoryi* are not of such a bright roseate color as those of *E. Wislizeni* but fully as formidable. The flowers of *E. Emoryi*, which are red, are succeeded by a yellow fruit, also dry and insipid. This species is found farther south, in Sonora, Mexico, more abundantly than in Arizona. Another very spinose cactus found on this desert is *Echinocereus Engelmanni*, growing in clumps of from two to twenty joints, as thick as one's arm, and a foot in length. In April it is covered with many large, fragrant, roseate flowers. Near by and generally under cover of a sagebrush or other plant, is seen the pretty cinereous *Cactus Grahami*. Individuals of single joints grow to the height of eight inches, but more frequently a number are growing from a common base, covered by many fragrant little flowers in May, if not earlier ; color, light roseate, with a white stripe in center of each petal. The small red fruit, naked and elongate, is quite persistent. This cactus flowers a second time after the July rains, if such occur. During the season of drouth in 1900, when we had only three good rains in twelve months, this *Cactus* prolonged its second time of flowering until a late November rain, and at Christmas time it was in full bloom on the Phoenix desert. A goodly number of *Covillea Mexicana*, the evergreen greasewood or creosote bush, was also blooming there for the second time. Both of these plants, in lateness of flowering, vie with our garden roses and chrysanthemums.

Of *Opuntia*, several species occur in this vicinity, of which the most noteworthy is the arborescent prickly pear, *Opuntia arborescens*, with its color variations. These plants grow from three to five feet high, have twisted joints, and may be found in any soil from comminuted granite to sandy loam. The flowers are eaten by several beetles, so that frequently very few perfect flowers are seen on a plant. Plants having flowers of magenta color represent *O. arborescens*, and the plant usually is known as the candle cactus. Another plant, with reddish-crimson flowers, is *O. arborescens versicolor*, which is also called candle cactus. *Opuntia Whipplei spinosior* has greenish-yellow flowers, and the branches are fortified with long and stout spines.

Opuntia Bigelovii is the dreaded " cholla " of the Mexicans. Its branches are thickly covered by long, barbed and sheathed spines, whitish and pendulous on large plants. These break off readily and adhere to clothing ; the ground all around is covered with these spines, and woe to the unlucky one treading on them with any but the heaviest of shoes. The pain is greater in withdrawing the spine than when they enter the flesh. Plants grow from two to twelve feet high or higher. Cowboys wear stout leather leggings to protect their limbs against the cholla. The flowers are greenish and the fruit greenish-yellow. A very slender *Opuntia* growing along the arroyos of our desert is *O. leptocaulis*, two feet high, with long stems of the thickness of a stout pencil. It has greenish flowers, succeeded by very small scarlet fruit, of strawberry shape, which remain long on the stem and look pretty. This plant grows in thick bunches. *Opuntia Engelmanni*, a plant of spreading habit, is found on the edges of the Phoenix desert, near the foothills. Its large ovate joints bear yellow flowers, and a large scarlet fruit the size of a pullet's egg. The latter is edible, refrigerant and yields a fine jelly. Animals, birds and even mankind resort to this fruit when provisions give out.

Cereus Greggii, our only night-blooming *Cereus*, is found sparingly on the sagebrush desert. Its flower is salvershaped, white and fragrant, over five inches in diameter. It seldom fruits ; the fruit is in shape like a miniature torpedo, scarlet and containing many black, flattish seeds. The root grows to very large size, and is fleshy like a beet. It is called by Indians and Mexicans the " Montezuma yam." I have dug up plants with a root two feet long, weighing from ten to fifteen pounds each. It will do best in a very sandy loam. Natives make use of this root for burns and other inflamed surfaces, cutting off a slice from a growing plant, and applying it to the affected parts. The stems do not grow very long, from two to four feet at most. Usually these plants grow under a mesquit tree or beside a tall sagebrush, to shelter the slender stem from the force of our wind or sandstorms. The stem is from one half to one inch thick, four- or five-angled, bluish-green and short-spined. I obtained fruit by cross-fertilization in the garden.

Other striking plants of our desert are two species of "palo verde," of which one is *Parkinsonia microphylla*, scattered all over the barren soil, and growing out of crevices of the rock like a succulent. It is not a large tree, and being hard in texture, it is much used for firewood. The leaves appear late in autumn or after the winter rains, and drop in April, when the tree is covered by panicles of yellow flowers, attracting many insects. The hard seeds are shelled out by birds, and the bark is gnawed off by the lemur-like desert squirrels and rodents. The pinnate leaves of this species have leaflets not larger than the head of a pin. This tree grows on the mesa as well as on mountains.

Parkinsonia Torreyana is a much handsomer tree, and its leaves, much larger than those of the preceding species, also appear at the approach of winter. The branches are more graceful; they are pendant, and when covered by the large yellow panicles of flowers early in April present a gorgeous appearance. This species affects the arroyos or watercourses more than the other. Young trees are quite bushy in shape. The branches of all Parkinsonias are prickly. The seeds of *P. Torreyana* furnish food for birds, and its flowers bread for bees.

Acacia Greggii is another very prickly desert bush, which in sheltered situations retains its small leaves all winter. In May it is covered by small, yellow, fragrant flowers furnishing fine bee-food. The branches having hooked thorns, it is known as the cat-claw acacia, and is much dreaded. It bears twisted brown flat pods. Its height is from five to ten feet.

Covillea Mexicana, or creosote bush, is the commonest evergreen shrub of the cactus desert, growing from four to ten feet high. Its branches are covered with a reddish-brown resin, which gives them a peculiar odor resembling creosote. A few beetles and plant-bugs resort to the yellow globose flowers which cover the bush in April. Later in autumn, after the rains, it flowers a second time, and it is then that the new foliage looks the best and remains so during the winter months. It imparts to the desert a lively green. By Mexicans it is used when planted young and trimmed like boxwood as a hedgeplant around graves. It is likewise medicinal. A tincture prepared from the fresh twigs is useful for sore throat, possessing astringent and antiseptic properties. A decoction is used for itching hemorrhoids, and also as a good wash for itching on any part of the body. Ranchers use a decoction to heal sores and foul ulcers on live stock.

Olneya Tesota is a leguminous tree growing generally along the desert ravines or arroyos, and furnishes next to mesquit the best fuel of this region. Mexicans call it "arbol del hierra" or ironwood. It is very thorny throughout and often grows to the height of twenty or thirty feet. The grayish-green color of its pinnate leaves is quite in contrast with the brighter green of other evergreen shrubs or trees of the desert. In the month of May the branches are loaded down with racemes of lavender and brownish-purple flowers, fragrant and much visited by bees. It is one of the few trees furnishing shade to freighters and travelers of the Arizona desert.

Lycium Fremontii, or squawbush of the prospectors, is quite an ornamental shrub of the outskirts of our cactus desert. From late in December until March it is thickly covered with fleshy, dark green, obovate small leaves, much resembling those of a *Sedum* or some species of *Mesembryanthemum.* After a frosty night the leaves present a crystalline appearance like an ice-plant. The shrub is thickly branched, and from three to six feet high, presenting a somewhat spherical shape. Its small, tubular, violet flowers are of the same length as the scarlet obovate fruit, and are rifled by many bees. It is the first bee-food of the season and of much value to the apiarian. Flowering and fruiting for several months in succession, this shrub is quite ornamental as well as useful. The berries have demulcent, slightly subacid properties and are eaten by birds as well as boys. Chickens feed on the succulent leaves. During the hot season this shrub is dormant, but after the rains of August, should there be any, it is again clothed in verdure, flower and fruit. Such is the case with many Arizona plants of the Sonoran flora.

Holacantha Emoryi, the crucifixion thorn of Mexicans, although not an evergreen shrub in the strict sense, being leafless and the thorniest of ugly thorns, is nevertheless green the year round. Every branch is clothed with sharp rounded thorns from one to four inches long. Its clusters of orange and red flowers closely attached to the axils or bifurcation of the thorns, appear in May and June, followed by fruit in July and August. Flowering branches are preserved for the use of tourists, and offered for sale in the curio shops of Arizona. The size and thickness of the thorns remind one of *Gleditsia triacanthos*. This shrub grows from two to six feet or more in height.

Artemisia tridentata, the well-known sagebrush of the desert, with the minute grayish-green leaves, attracts much less attention in appearance than size. It grows from three to eight feet or more in height according to soil. In the more sandy parts of the desert, it provides shelter for many tender if not more useful plants. The small *Cactus Grahami* thrives in its shade, and the slender, fragile branches of *Cereus Greggii* find a support growing through its mass of slim branches.

Another *Artemisia*, apparently undescribed, is much handsomer, of a brighter green color and with large leaves. It affects the region of the cactus, growing in more rocky and sandy soil. Its height is from one and one half to two and one half feet.

Ephedra trifurcata, or "cañatilla" of the Mexicans, is a strange looking shrub, leafless and with sheathed branches like *Equisetum*. Its branches are closely crowded, of the thickness of a straw or less, and of a grayish-green color. It is a shrub from three to five feet high, and very many stems are given off from a common root. It affects the arroyos and swales of the desert in preference to drier situations. The Mexicans use this plant extensively in the form of decoction for specific urethritis, and hold it in high esteem. *Ephedra antisyphilitica*, a closely allied species found nearer to the Mexican boundary and further south, is also much used in Mexico for similar purposes and as a diuretic. This plant is two feet in height.

PHOENIX, ARIZONA.

New Species from the Pacific Coast.—I

By Edmund P. Sheldon

Cheiranthus Pacificus Sheldon sp. nov.

Perennial, slender, erect, 3–6 dm. high, usually simple, sometimes branched above and rarely several-stemmed from the somewhat woody base after the first year: stems green or slightly purplish at the base, slightly 6–9-angled above, the angles becoming mere lines below, pubescence short, appressed: leaves lanceolate, 1-nerved, narrowed to a sessile, subclasping base, entire to remotely runcinate-toothed, acuminate at the apex, pubescence appressed, once or twice forked: inflorescence subcapitate, eventually developing into a lax raceme of erect or divergent pods: sepals 5–6 mm. long, the outer often 2–3-toothed at the apex: petals relatively small, 6–12 mm. long, yellow: pods 5–10 cm. long, quadrangular, acute or short-acuminate at the apex, the persistent stigmas small, and but slightly lobed: seeds lenticular, with a hyaline wing at one end.

This species has hitherto been referred to *C. asper* Nutt., but its relationship is rather with *C. inconspicuus* Greene and *C. angustus* Greene.

A study of the seeds of the species of *Cheiranthus* in the Herbarium of the California Academy of Sciences seems to show that those of *C. asper* and its near relatives are quadrangular and truncate at one end, often apiculate on the other. The present species is characterized by lenticular seeds with a wing-like appendix.

The present known range of this plant is from northern Oregon to southern California.

The type is my no. 11008 from Multnomah Falls, Multnomah Co., Oregon, July 27, 1902. I found it in abundance on open, exposed banks near the Columbia River. It is also represented in the Herbarium of the California Academy of Sciences by the following specimens: Hornbrook, Siskiyou Co., Calif., *Curran;* Santiago Creek, Orange Co., Calif., *Agnes Bowman;* Salt Creek, Tulare Co., Calif., *A. Eastwood;* Ketten Pum, Trinity Co., Calif., *Blankinship;* Mt. Tamalpais, Marin Co., Calif., *A. Eastwood;* New Idria, San Benito Co., Calif., *A. Eastwood;* Dunlap, Fresno

Co., Calif., *A. Eastwood;* San Bernardino, Calif., *Parish Bros.* no. 61.

✓ **Nemophila mucronata** Eastwood sp. nov.

Stems decumbent, 1–1.5 dm. long, branched from the base, flat, winged, glabrous, with internodes 2–3 cm. long: leaves 3–5-lobed, with blades about as long as the broad petioles, together 1–2.5 cm.; lobes oblong, mucronate, upper surface bright green, clothed with fine hairs which are papillate at base, lower surface paler, margin inclined to be revolute; petioles broadening, with clasping ciliate base: flowers axillary: peduncles longer than the leaves, glabrous, winged, curved downwards in fruit: calyx with appendages half the size of the triangular divisions, both with appressed hairs on both sides, ciliate, mucronate: corolla tubular-campanulate, apparently white, the rounded divisions 2.25 mm. broad, 4 mm. deep: filaments ribbon-like, narrowing upwards, one half as long as the corolla, inserted above the base: anthers dark brown (?), mucronate: corolla-appendages consisting of two small ciliate folds on each side of the filaments: capsule suborbicular, 5 mm. in diameter: seeds (immature) with prominent caruncle.

This is nearest *N. micrantha* Eastwood, from which it differs chiefly in the mucronate lobes of the leaves, calyx divisions and anthers, as well as a slight difference in the form of the corolla appendages. Collected at Chenowith Creek, Wasco Co., Oregon, by Mr. Edmund P. Sheldon, April 25, 1902, being no. 10204 of his collection.

Aster mucronatus Sheldon sp. nov.

Erect, 9–12 dm. high: stem minutely pubescent above, glabrous below: leaves linear, sessile, acute or acuminate with mucronate somewhat calloused tips, smooth beneath, scabrous with short appressed hairs above, becoming glabrate, entire or remotely denticulate with small appressed teeth, margins scabrous; those of the stem 2–8 cm. long, those of lateral branches 1–2 cm. long: inflorescence loosely subpaniculate, the lateral branches often leafy: heads 2 cm. broad; involucral bracts spatulate, foliaceous, with scarious base and margins, slightly glandular, with acuminate mucronate tips, especially the outer and broader ones; rays linear strap-shaped, slightly erose at the apex: pappus 1 cm. long: achene pubescent.

Near to *Aster hesperius* Gray, a species of Arizona and New Mexico.

This plant was found in abundance around the edge of upland meadows near Mt. Scott, Multnomah Co., Oregon, Aug.–Oct. 1902, no. 11171.

✓ **Aster umbraticus** Sheldon sp. nov.

Erect, stems slender, glabrate, purplish, simple, often several from the same root, 15–30 dm. high: leaves thin, sessile, glabrous, the margins scabrous, lanceolate, acuminate, divergent, dentate, with small remote salient teeth, or entire, becoming smaller above: inflorescence loosely paniculate, the heads 2 cm. broad, singly terminating the slender branchlets: involucral bracts acute, 2 cm. long, green with scarious margins; rays linear strap-shaped, lilac: achene very small, brownish, glabrous.

Nearly related to *Aster foliaceus* Lindl., but different from any of the numerous varieties of that species.

This plant grows in semi-shaded places along the banks of the lower Willamette River. The type is from University Park, Multnomah Co., Oregon, Sept. 14, 1902, no. 11310.

✓ **Artemisia arachnoidea** Sheldon sp. nov.

Perennial: stems 6–12 dm. high, from a somewhat woody base, simple or sparingly branched, striate, arachnoid with long loose hairs: leaves scattered, lanceolate, acuminate, sessile, smooth above, arachnoid beneath, entire or the lower irregularly laciniate-lobed with 3–4 divergent acuminate lobes: infloresence paniculate, subsecund, with slender branches 3–10 cm. long, upon which are scattered the short pedicellate heads: heads borne singly or in pairs, subtended by minute bracts: involucre broadly campanulate, the bracts slightly arachnoid, becoming smooth, scarious with a green center: flowers all fertile, light yellow, brownish in drying: receptacle glabrous.

This species is nearest to *Artemisia elatior* (T. & G.) Rydb. The subsecund loose inflorescence and peculiar involucral bracts are characteristic. It was collected on the sandy banks of the Columbia River, one mile west of Vancouver, Washington, Aug. 31, 1902, no. 11284.

✓ **Agoseris maritima** Sheldon sp. nov.

Perennial from a simple or rarely branched caudex which is buried in the sand, and emits an orange yellow juice when bruised: leaves clustered at the top of the caudex 0.75–1 dm. long, spatulate, mucronate, remotely dentate, sparsely short-pubescent, becoming glabrate, the narrowly margined petioles slightly enlarged and scarious at the base: peduncles as long as the leaves when in flower, twice as long when in fruit, striate near the top, slightly pubescent with loose hairs: involucral bracts green, blotched or spotted with purple, with a purple median line, slightly pubescent, the outer oblong, obtusely mucronate, the inner twice the length of the outer, lanceolate, acuminate : corollas yellow, slightly exceeding the involucre, the outer row with longer, purple blades : achenes brownish, 10-ribbed, 5 mm. long, tapering to a slender beak of equal length : pappus dull white, 5 mm. long, receptacle flat, areolate, with a short persistent chaff.

This species is perhaps near to *Agoseris apargioides* (Less.) Greene. But a study of that species as it occurs in the vicinity of San Francisco, convinces me that it is entirely different. The reddish-orange juice and paleaceous receptacle are noteworthy.

Abundant on the sand dunes of Clatsop Beach near West, Clatsop Co., Oregon, Aug. 21, 1901, no. 11250.

PORTLAND, OREGON.

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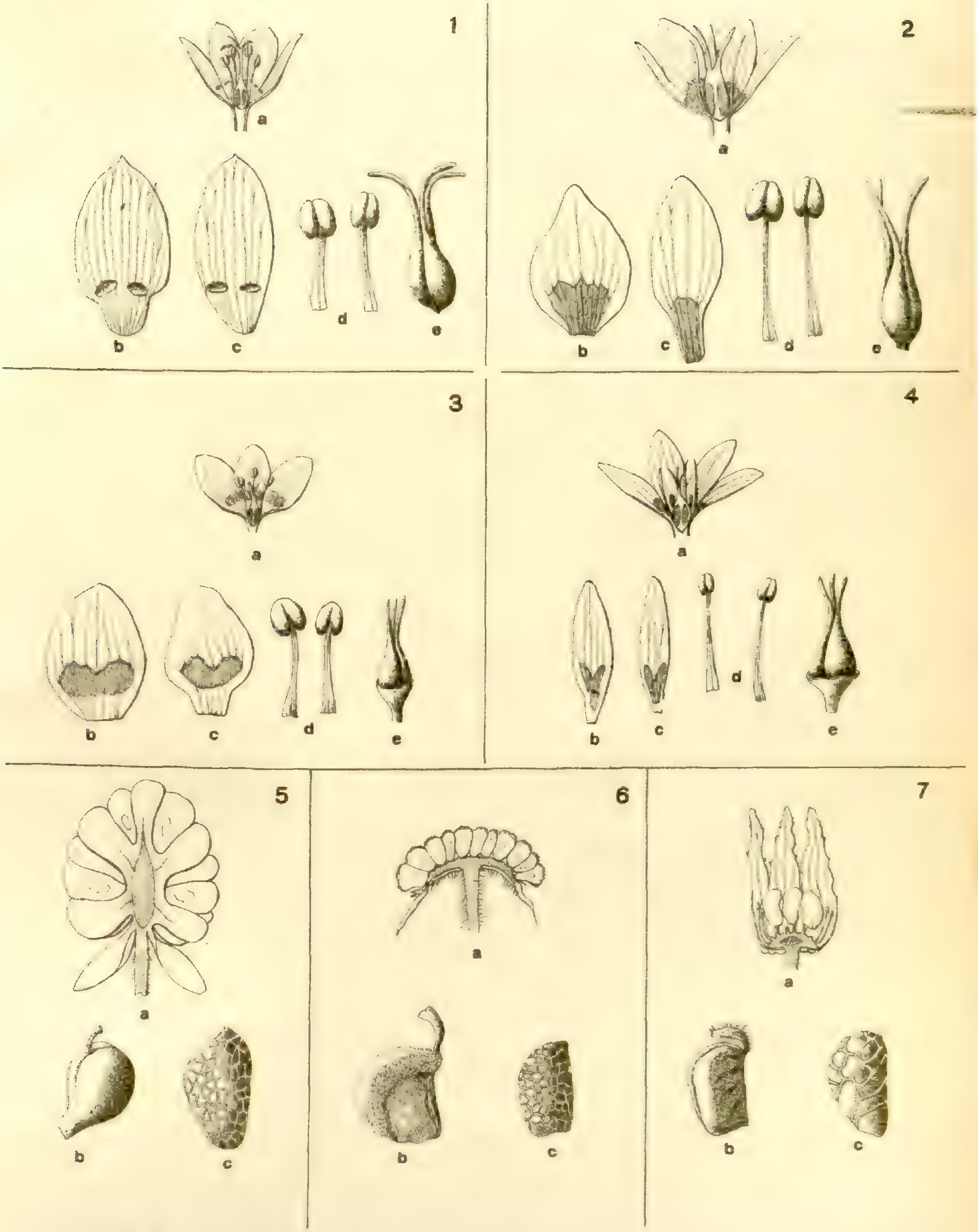
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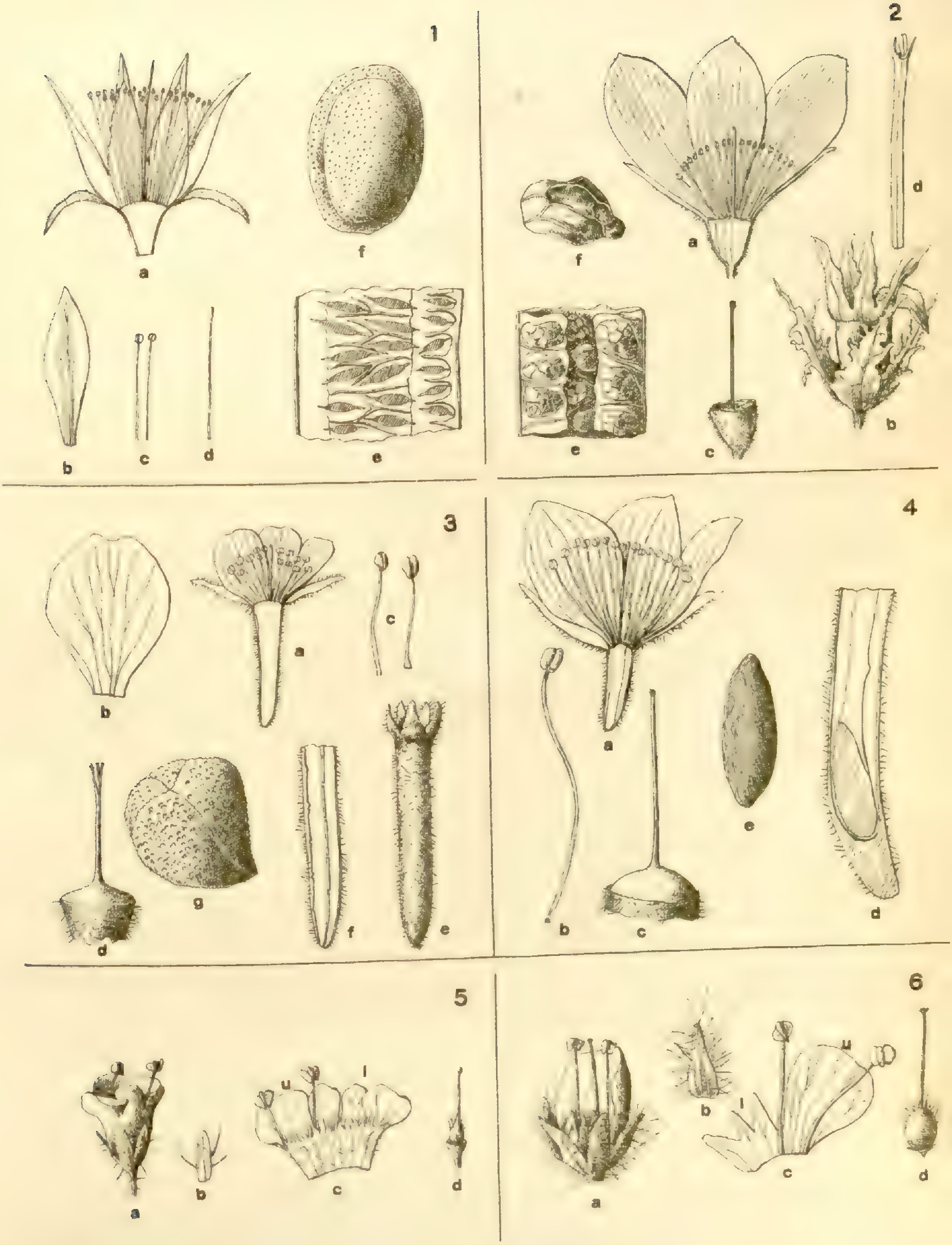
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BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE, 1903

Botanical Explorations in Georgia during the Summer of 1901.— II. Noteworthy Species

By ROLAND M. HARPER

Unless otherwise noted, the plants mentioned below were collected on my expedition of 1901, the itinerary of which was described in the last number of the BULLETIN.

ADIANTUM CAPILLUS-VENERIS L.

Although this interesting fern has not yet been reported from Georgia by any other botanist, it is quite widely distributed in the lime-sink region. Last summer * I found it quite adundant in Dooly County (no. 1064) not far from where I first discovered it several years ago, also in the central part of Lee County (no. 1161), and in all the lime-sinks visited in Decatur County, especially at Forest Falls (no. 1193). The illustration of this waterfall in the geological bulletin already mentioned led me to suspect very strongly the occurrence of the *Adiantum* there, and evidence in support of this suspicion accumulated as I drew near the place. In Camilla I was told that "a maidenhair fern, different from the one in the mountains," grew at Forest Falls, and in Thomasville the next day I saw specimens of it in cultivation which were said to have been obtained there. On the inaccessible perpendicular side of the sink, within reach of the spray of the waterfall, it grows most luxuriantly.

---

* As this paper was mostly prepared in the spring of 1902, such phrases as this of course refer to 1901.

[The preceding number of the BULLETIN, Vol. 30, No. 5, for May, 1903 (**30**: 271–318, *pl. 13, 14*), was issued 16 My 1903.]

ADIANTUM HISPIDULUM Sw. Syn. Fil. 124. 1806

Collected in an apparently unused well in the outskirts of Thomasville, where it was accompanied by *Woodwardia areolata*, on the morning of August 9 (no. 1171). As far as I know, this Old World species has never been reported as growing spontaneously in the United States. It was fairly abundant and fruiting copiously, and seemed as much at home as the *Woodwardia*, which is a common inhabitant of wells in South Georgia.*

ISOETES FLACCIDA Shuttl.

This species (or some forms of it) is represented in my 1901 collection by five numbers, all from the coastal plain, though no species of *Isoetes* had previously been reported from the coastal plain of the southeastern United States outside of Florida.

Numbers 843 and 951, partly emersed, were collected in June in a sluggish pine-barren stream in Bulloch County, and no. 1112 was found in a similar situation in Sumter County, July 24. It is not absolutely certain that these three numbers represent the typical *I. flaccida*, which grows in "lakes and clear streams, middle and west Florida," and is said † to mature in April and May and disappear in June.

Number 1010 is a plant of rather different habit and habitat. It was found in wet pine-barrens around a mayhaw (*Crataegus aestivalis*) pond in Sumter County, and was a smaller and stiffer plant than the others. It grows in the greatest abundance, but so concealed by the tall grass that one might walk over it day after day without suspecting its presence. I only discovered it accidentally by pulling up a specimen with another plant, but on getting down on my knees I found it in apparently inexhaustible quantities. At that time, July 5, there was more water in these pine-barrens than I ever saw before or after, and yet none of the *Isoetes* was completely submersed, so it is almost a strictly terrestrial plant. The principal species accompanying it were *Sagittaria* sp., *Eleocharis tricostata*, *Rhynchospora Tracyi*, *Rhexia aristosa*, *Sabbatia campanulata*, *Breweria aquatica*, *Gerardia linifolia*,

---

*On a subsequent visit (Sept. 18, 1902) the *Adiantum* was found to be still flourishing.

† Engelm. Trans. Acad. Sci. St. Louis, **4**: 386. 1882.

Helenium sp., and *Rudbeckia Mohrii.* I did not revisit the locality until August 22, at which time the *Isoetes* seemed to have completely disappeared, but a careful search revealed its dead and withered leaves lying flat on the moist ground, and the ripe sporangia buried just below the surface.

Number 1046, collected on July 11 around a cypress (*Taxodium imbricarium*) pond near Cobb in the same county, had much the same appearance, though differing slightly in habitat. These two numbers last mentioned are referred by Mr. A. A. Eaton, who has examined some of my specimens, to *I. flaccida rigida* Engelm. (Trans. Acad. Sci. St. Louis, **4**: 386. 1882), which he considers merely a later emersed state of *I. flaccida.* There are some discrepancies between my specimens and the original description of this variety, as regards season and habitat, but these may perhaps be due only to the difference in latitude, the original specimens having come from south Florida.

The above observations on *Isoetes* are mentioned chiefly to show the great necessity for further field work on the southern species, and to indicate that the genus may be found much more abundant in the Southern States than at present supposed.

SAGITTARIA ISOETIFORMIS J. G. Smith, Rep. Mo. Bot. Gard. **6**: 115. *pl. 53.* 1895

This interesting little plant was collected on the muddy margin of a small pine-barren pond in Decatur County, between Forest Falls and Bainbridge, August 12 (no. 1198), where it was accompanied by *Eleocharis tricostata*, and it was seen a few hours later in and around Open Pond, in the same county. It seems to have been known hitherto only from peninsular Florida.

The specific name is a most appropriate one, doubtless more so than its author realized. The submersed sterile form grows in great abundance in the shallow clear water of Open Pond near the shore, just as *S. graminea* does in New England, and it is here impossible to distinguish it from *Isoetes* without close examination.

CYPERUS RETROFRACTUS (L.) Torr.

While walking along the summit of the Pine Mountain range in Meriwether County, on the 29th of August, I noticed for the first time that this species has an adaptation for dissemination by animal agencies. After passing through a patch of it I found many of the spikelets adhering to my clothes by their sharp points. I do not know whether any other species of the genus behaves in the same way, but not many of them have the reflexed spikelets which are an essential feature of this mode of dissemination.

CYPERUS IRIA L.

This introduced species was found rather common in cultivated fields in the Chattahoochee River bottoms in Early County, August 14 (no. 1224). Not previously reported from Georgia, Florida or Alabama, though there can be little doubt that it grows also on the other side of the river in the other two states.

Scirpus fontinalis sp. nov.

Culms tufted, 12–18 dm. long, triangular at least below, the summits very slender and nodding. Basal leaves few, 3–4 dm. long by 3–5 mm. wide; stem-leaves few or several, ascending or almost appressed, slender and acute: umbels compound, unequal-rayed, axillary and terminal, the 1–4 lateral ones on slender flattened drooping peduncles 1–3 dm. long: spikelets (often partly transformed into tufts of leaves) all on slender pedicels, 2–3 mm. thick, oblong when young, their axes elongating as the lower scales drop off and becoming finally about 1 cm. long: scales oblong, acute, concave, 1.5 mm. long, with scarious whitish margins and green keels: bristles 6, smooth, tortuous, about as long as the achene: achene light brown, oblong, triquetrous, 1 mm. long, acute at both ends, covered with minute depressed conical papillae, and tipped with the short slender base of the style.

This species is somewhat intermediate between *S. divaricatus* Ell. and *S. lineatus* Michx., but is abundantly distinct from either. It resembles the latter (which has not yet been reported from Georgia) in having axillary umbels, but differs in most of its essential characters, such as its smaller spikelets and pointless green scales, and others more difficult to describe. From *S. divaricatus* it is readily distinguished by its slender nodding culms, ascending leaves, long internodes and long-peduncled axillary umbels, as well as by its thicker spikelets and papillose mucronate achenes, and by its habitat. *S. divaricatus* is a stouter usually erect plant, with numerous widely spreading or deflexed leaves and a single diffuse terminal umbel, generally inhabiting muddy swamps of creeks and rivers. It too is often proliferous late in the season, but the tufts of leaves spring from the nodes oftener than from the inflorescence. (This character is well shown in my no. 1142, collected in the swamp of Muckalee Creek above Americus, July 30.) In all the specimens of *S. divaricatus* examined I have observed no deviation from a strictly terminal umbel, while in the species under consideration every specimen I saw had at least one lateral one.

The specimens of *Scirpus fontinalis* were collected in the shallow margin of a shaded pool of clear cool water issuing from a spring within the corporate limits of Leslie, Sumter County, on the afternoon of July 6 (no. 1012). It was accompanied by *Cyperus strigosus*, *Scirpus Eriophorum*, *Rhynchospora miliacea*, *Juncus setaceus*, *Polygonum setaceum*, *Samolus floribundus*, and other semi-aquatic plants. The temperature of the water was taken the same afternoon and the next morning, in different parts of the pool and at various depths, and was found to be in every case 68° Fahrenheit. It probably does not vary much from this point throughout the year. A fragment of fossiliferous rock from the hillside just above the spring was sent to the U. S. Geological Survey and identified as being probably of the Zeuglodon horizon (uppermost Eocene). The chemical composition of this rock has not been determined, but the water issuing from it is reputed to be limestone water.

ELEOCHARIS ROBBINSII Oakes

On July 13 I found in the northern part of Lee County a pine-barren pond perhaps ten acres in extent and two feet deep in the middle, almost filled with this species (no. 1068), growing so luxuriantly as to conceal the water. This seems to be the only station reported for it between Delaware and Florida. The only other plants seen in the deeper parts of the pond were *Homalocenchrus hexandrus* and a few small *Cephalanthus* bushes. Around the margins of the pond were observed among other things *Sporobolus compressus*, *Rhynchospora fusca*, *R. Tracyi*, *Scleria gracilis*, *Polygala ramosa*, *Stillingia aquatica*, *Rhexia aristosa* and *Boltonia diffusa*, some of which have an equally remarkable distribution.

RHYNCHOSPORA FUSCA (L.) Ait. f.

Collected on the sandy margin of a pine-barren pond in the northern part of Lee County (as just mentioned) July 13 (no. 1067). This species has apparently been reported but once before from the Southern States. Mr. M. L. Fernald * mentions its having been collected by A. H. Curtiss, at Milton, Santa Rosa County, Florida (no. 5929, July 8, 1897). The specimen under this number in the U. S. National Herbarium looks very much like mine, but the one at the New York Botanical Garden has a somewhat different appearance and may not represent the same species. I have more recently discovered that Mr. Nash's no. 1321, from the sandy shore of Lake Juana, Lake Co., Florida, July, 1894, distributed as *R. gracilenta*, is also *R. fusca*, at least the representation of it in the U. S. National and Columbia University herbaria; and Mr. Fernald informs me that the material in the Gray Herbarium is the same. These southern specimens differ from northern and European ones in being a little more slender, but otherwise seem to be identical.

RHYNCHOSPORA DODECANDRA Baldw.

Collected on the rosemary sand-hills of Emanuel County, where it is one of the most characteristic species, June 28 (no. 977); also in very dry white sand about two miles from Open Pond, Decatur County, August 13 (no. 1216), where it was associated with *Paronychia riparia*, *Dicerandra linearifolia*, *Serenoa* and *Stipulicida*. It does not seem to have been reported from Georgia before, or so far inland, these two stations being about sixty miles from the coast.

MAYACA FLUVIATILIS Aubl.

Mr. Fernald has recently reported † the collection of this South American species by Mr. Curtiss last year in Florida. It is represented in my 1901 collection by no. 1179, from a cypress pond in Thomas County, August 9. There are some differences between this species and *M. Aubleti* which Mr. Fernald failed to mention. The leaves of *M. fluviatilis* are much longer and more acute, exceeding the peduncles, and the capsule is oblong instead of globose. My specimens were completely submersed, while *M. Aubleti* usually grows in sandy bogs rather than in ponds. I have not been able to detect any essential difference in the finely sculptured seeds, however.

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* Bot. Gaz. **24**: 433. D 1897.

† Bot. Gaz. **33**: 154. 21 F 1902.

On August 12 I saw what was probably the same plant in Decatur County, but did not collect it. There are quite a number of specimens referable to this species in the U. S. National Herbarium and that of Columbia University, mostly from Florida.

XYRIS SMALLIANA Nash, Bull. Torrey Club, **22**: 159. 1895

Collected on the morning of July 19 (no. 1096) in a shallow pond in the woods south of Omaha, Stewart County, where it was abundant, and accompanied by *Panicum digitarioides*, *Scirpus cylindricus* (no. 1095), *Pontederia cordata*, *Castalia odorata* (no. 1097), *Brasenia purpurea*, *Limnanthemum aquaticum*, *Monniera Caroliniana*, *Utricularia purpurea* and other interesting plants. Previously reported only from the type-locality in Florida.

✓ **Xyris scabrifolia** sp. nov.

Plants solitary, grayish green. Roots fibrous: stem with a slightly bulbous base 6–8 mm. in diameter, enveloped in the pale striate membranous sheaths of the leaves: leaves 1–3, usually 2, erect, acute, slightly twisted, 3–4 dm. long, about 3 mm. wide at the middle, tapering below (about 1.5 mm. wide just above the sheath), the whole surface of the blade minutely transversely rugose; uppermost sheath 12–15 cm. long, very obliquely truncate, acute: scape 5–7 dm. tall, 1–2 mm. in diameter, terete except for a minute longitudinal ridge on one side, pale and rugose like the leaves: head oblong, about 12 mm. long and 8 mm. thick at maturity: scales oblong, entire, the largest 7–8 mm. long: lateral sepals lanceolate, about 3 mm. long, the narrow wing of the keel lacerate above the middle: corolla yellow.

This species seems nearest to *X. Caroliniana* Walt., but differs from that and all other species known to me in the rugose, almost scabrous, surface of its leaves and scapes. This peculiar rugosity makes it as rough to the touch as some species of *Equisetum*, such as *E. laevigatum*. It differs further from *X. Caroliniana* in its terete scape and pale sheaths. It is a very slender plant, resembling in this respect *X. flexuosa* Muhl. (especially southern specimens of that species).

My specimens were collected on August 28 in an open bog near Woodbury, Meriwether County, at about 775 feet altitude (no. 1254). They were accompanied by an interesting association of plants, most of them coastal plain types, such as *Lycopodium pinnatum* (no. 1255), *Eleocharis tuberculosa*, *Rhynchospora axillaris*, *Juncus trigonocarpus* (no. 1253), *Polygala cruciata* (no. 1257), *Eryngium virgatum* (no. 1252) and *Gratiola pilosa*. This locality is about 25 miles from the nearest part of the coastal plain.

Before this time apparently only two or three of our North American species of *Xyris*, namely, *X. flexuosa*, *X. montana* and perhaps *X. Caroliniana*, had been known outside of the Atlantic coastal plain, and it is noteworthy that in these three species *X. scabrifolia* finds its nearest relatives.

Dr. Engelmann, in Plantae Lindheimerianae,* described a variety *scabra* of *X. Caroliniana*, but his plant is now treated as identical with *X. flexuosa*, and his description shows that it is quite different from my plant.

In Dr. Mohr's herbarium (now deposited in the U. S. National Museum) there is a specimen which is doubtless my *X. scabrifolia*, mounted on the same sheet with two specimens of *X. flexuosa* collected near Mobile, July 14, 1883.

JUNCUS MEGACEPHALUS M. A. Curtis

Collected in low grounds just back of the sand-dunes on Tybee Island, June 21 (no. 925), where it was accompanied by *J. aristulatus* (no. 926) and several other plants mostly maritime; also in a moist shaded sandy place among the lime-sinks east of Muckalee Creek in Lee County, August 2 (no. 1159), with *Cyperus cylindrostachys*, *Dichromena colorata* (no. 1157) and one or two other species which I had previously seen only along the coast.

The differences between this long-neglected species and its relatives were well pointed out by Mr. Coville † several years ago, and my specimens agree perfectly with his description; they have also been examined by him and compared with authentic specimens. I do not find that this species has been reported from

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* Boston Jour. Nat. Hist. **5**: 235. 1845.

† Bull. Torrey Club, **22**: 302–305. 1895.

Georgia before. It seems always to indicate the absence of the Lafayette formation.

JUNCUS DIFFUSISSIMUS Buckley

On July 3 I found a most luxuriant growth of this species (no. 995), in a marshy place near Stillmore, Emanuel County, thus extending its known range about 150 miles farther eastward than the station reported by me * last year. Associated with it were *Panicum scabriusculum*, *Sagittaria Mohrii* (no. 994), *Eleocharis tuberculosa*, *Juncus Elliottii*, *J. polycephalus*, *J. trigonocarpus*, *Sarracenia rubra*, *Rhus Vernix* and other species of more or less interest, the *Sagittaria* being also considerably farther east than it had been reported before.

IRIS VERNA L.

This species, usually in the southeastern states an inhabitant of dry pine-barrens, was collected on August 29 on the northern slopes of the Pine Mountains in Meriwether County, at about 800 feet altitude (no. 1266), and seen five days later and 200 feet higher in dry woods in Campbell County, but without traces of flower or fruit at either locality.

As noted by Dr. Small † a few years ago, the leaves of this species become considerably elongated in summer, but he failed to mention the interesting fact that although equitant, they are decidedly dorsiventral, being bright green on one side and glaucous on the other. They spread out like a fan and bend away from the rootstock (which is perpendicular to the plane of the leaves), in this way bringing the green side uppermost.

GYMNADENIOPSIS NIVEA (Nutt.) Rydb.

Habenaria nivea (Nutt.) Spreng.

Collected in the pine-barrens of Bulloch County, June 15 and 26 (nos. 892, 954). One of the specimens of the latter number was the largest I ever saw, being nearly 6 dm. tall, with about sixty flowers in the spike. The object of mentioning this species here, however, is to note that the flowers are plainly 5-ranked in the spike, as may be readily ascertained by looking at a living plant endwise. I have never seen this character mentioned before, and do not know how many species share it, but it is certainly not the case with all orchids, or even with all spicate ones, as for instance in *Gyrostachys*, different species of which have the flowers in one, three or four ranks.

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* Bull. Torrey Club, **28** : 469. 1901.

† Bull. Torrey Club, **24** : 175. 1897.

PARONYCHIA HERNIARIOIDES (Michx.) Nutt; Spreng. Syst. **1**: 822. 1825 *

Collected on the ordinary sand-hills along Big Lott's Creek in Bulloch County, June 17 (no. 912), and on the rosemary sand-hills of Emanuel County, June 28 (no. 978); also seen on July 3 in similar situations in Tattnall and Montgomery Counties, especially along the left bank of the Little Ocmulgee River at the western border of the latter.

This species has usually been described as prostrate, but incorrectly. Young specimens, like no. 912, have much the habit of *Anychia dichotoma*, while fully developed specimens, such as no. 978, have the numerous branches very widely speading, making the plant considerably broader than high, but they seem to be strictly self-supporting, and never show the slightest indication of being prostrate. Such a specimen when pressed has very much the appearance of *Euphorbia cordifolia* Ell., a strictly prostrate plant, and this is doubtless the cause of the error.

Cabomba Caroliniana pulcherrima var. nov.

Stem a meter or more in length, reddish-purple. Submersed leaves similar to those of *C. Caroliniana*, but dark-colored and with narrower segments. Peduncles tortuous. Petals bright purple. Floating leaves, calyx and fruit nearly as in the species.

Although further study may show this to be a distinct species, the differences at present known seem only to entitle it to varietal rank. The purple stem and petals are the most striking features. The latter are of exactly the same color as the corolla of *Utricularia purpurea*, for which species our plant might easily be mistaken a short distance away. I find no mention of a purple-flowered *Cabomba* in botanical literature.

Collected in three or four feet of water in Cane Water Pond,

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* The place of publication of *Paronychia herniarioides* is usually given as Nuttall's Genera, but in that work only the name appears, without synonymy or description.

Decatur County, on the morning of August 13 (no. 1209). The plant was pretty well distributed over the pond, though not in great abundance. The specimens which resemble mine most closely, of all the herbarium material I have examined, were collected by Rugel in 1843 in Lake Jamony (Iamonia) and near Tallahassee, Florida, but their age makes it impossible to tell what the color of their petals might have been. More recent specimens, collected near Tallahassee by N. K. Berg, and preserved in the herbarium of the New York Botanical Garden, show the purple petals quite distinctly, besides resembling mine in general appearance as much as do those of Rugel. Both of these localities are within forty miles of mine.

Castalia odorata latifolia var. nov.

Leaves floating in deep water, orbicular with narrow sinus and acute lobes, 4–6 dm. broad, the veins thick and prominent beneath and copiously anatomosing near the slightly upturned margins; flowers large, the longest petals about 1 dm. long. Otherwise very similar to *C. odorata.* (*Castalia reniformis* Nash: not *Nymphaea reniformis* Walt.)

The identity of Walter's *Nymphaea reniformis* * has long been a puzzle. His description, "foliis reniformibus, corollis polypetalis, loculis monospermis," does not fit any known plant, and Mr. E. G. Baker, of the British Museum, has informed me that there is no specimen of it in Walter's herbarium. Willdenow, Pursh and Elliott took up the species on Walter's authority, apparently without being themselves acquainted with it, Willdenow placing it in *Nelumbium*, probably on account of the phrase "loculis monospermis," which may have been an error. Delessert's figure, probably the only one which pretends to represent the species, shows a flower much like that of *Castalia odorata*, and a leaf with the basal lobes rounded as in *Nymphaea* (*Nuphar*), but with the venation of *Castalia*. If this figure is trustworthy (and it has the appearance of having been carefully drawn), it does not represent any species at present known, but it would be rash to deny that such a plant exists, until the Southern States have been better explored than they are at present. Delessert says of his plant "Crescit in Carolina (Fraser)," and it should be borne in mind that Fraser was acquainted with Walter, and is said to have attended to the publication of his "Flora Caroliniana" in London, so that he was in an excellent position to know Walter's species. DeCandolle says of *Nymphaea reniformis*, "(v. s.)," doubtless referring to one of Fraser's specimens, probably the same one from which Delessert's figure was drawn. So unless there is evidence to the contrary this figure must be accepted as representing Walter's *Nymphaea reniformis*, a species which should perhaps take rank with *Gordonia pubescens* and *Pyrola oxypetala* as being lost to science.

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* *Nymphaea reniformis* Walt. Fl. Car. 155. 1788; DC. Syst. **2**: 55. 1821; Delessert, Ic. Select. **2**: 3. *pl. 5.* 1823; DC. Prodr. **1**: 115. 1824.

Nelumbium reniforme Willd. Sp. Pl. **2**: 1260. 1799.

Cyamus reniformis Pursh, Fl. Am. Sept. 398. 1814; Ell. Bot. S. C. & Ga. **2**: 68. 1821.

Nymphaea odorata β Torr. & Gray, Fl. N. Am. **1**: 57. 1838.

N. odorata reniformis Lehm. Nymphaea, 13. 1853 (?)

In later years *N. reniformis* has been associated in synonymy with *N. tuberosa* Paine,[*] a northern species, but probably on insufficient grounds. About ten years ago Professors Trelease and Hitchcock independently transferred DeCandolle's *Nymphaea reniformis* to *Castalia*, apparently overlooking the fact that Walter was the author of the species. Professor Hitchcock's plant (from Iowa) is *C. tuberosa*, and the identity of that of Professor Trelease is immaterial, as he gave neither description nor synonymy. A few years later Mr. Nash [†] published the same combination, crediting the specific name correctly to Walter, but associating it with specimens collected by him in Lake Ella, Lake County, Florida, in 1894 (nos. 1153, 1180).

It is Mr. Nash's plant in which I am particularly interested, for I collected specimens which seem exactly to match his in Cane Water Pond, Decatur County, on the morning of August 13 last year (no. 1212). To avoid any possible confusion in the future,

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[*] *Nymphaea tuberosa* Paine, Cat. Pl. Oneida Co. N. Y. **132**. 1865.

Castalia tuberosa Greene, Bull. Torrey Club, **15**: 84. 1888; Britton & Brown, Ill. Fl. **2**: 44. *f. 1532*. 1897.

Nymphaea reniformis "DC." A. Gray, Manual, ed. 6. 56. 1890; Syn. Fl. N. Am. **1**: 76. 1895.

Castalia reniformis "(DC.)" Trel.; Branner & Coville, Rep. Geol. Surv. Ark. 1888^4: 164. 1891 (name only); A. S. Hitchcock, Trans. Acad. Sci. St. Louis, **5**: 484. 1892.

[†] Bull. Torrey Club, **22**: 147. 1895.

I will designate my own specimens as the type of the foregoing description. Similar specimens are in the Columbia University Herbarium, collected in Louisiana by Dr. Hale, and in Thomas County, Georgia, by Dr. Small in 1895. But this southern plant seems to differ from *Castalia odorata* only in its larger size and more prominent veins on the lower surface of the leaves, and is probably entitled only to varietal rank at the most. It cannot be the *Nymphaea reniformis* of Walter,* so I have given it a new name as above.

The leaves of my specimens were fully as large as those described by Mr. Nash, and their edges were often slightly upturned, as also noted by him, allowing the wind to get under them and turn them partly over. This plant is very abundant in Cane Water Pond, and its leaves and flowers are the most conspicuous objects on the surface of the water there.

NYMPHAEA ORBICULATA Small, Bull. Torrey Club, **23**: 128. 1896

On August 9 I visited the type-locality of this species in Thomas County for the purpose of securing some authentic fresh specimens for Dr. Gerrit S. Miller, Jr., who is doing some work on the genus, and I had little difficulty in finding it (no. 1178). Four days later it was seen in Cane Water Pond, in the next county.

I can now correct an unfortunate error in the original description. Dr. Small says of the leaves, "the upper leaves rough with irregular papillae," but in reality the upper surface is perfectly smooth in life, but becomes rough in drying, as in some other species of the genus. Dr. Small calls the locality "a small lake," but it is nothing but a cypress pond, the level of which has been artificially raised a few feet for fishing purposes by a dam, and it could hardly be dignified by the name of lake.

SARRACENIA MINOR Walt.

S. lacunosa Bartr. Travels, 417. 1791.

S. variolaris Michx. Fl. Bor. Am. **1**: 310. 1803.

In a previous paper † I referred to the probable identity of

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* See in this connection Robinson, Syn. Fl. N. Am. **1**: 76. 1895.

† Bull. Torrey Club, **27**: 428. 1900.

Sarracenia minor Walt. with *Sarracenia variolaris* Michx. Walter's description, though of course very brief, is amply sufficient to distinguish this species from any other now known, but to settle the question finally I wrote in May, 1901, to Mr. E. G. Baker, of the British Museum, asking if the species was represented in Walter's herbarium, and if so what it was like. He very kindly complied with my request, and informed me that such a specimen existed, and that it was evidently the same as *S. variolaris* Michx., the only trouble being that it was not labeled *S. minor* but *S. lutea*, a name which was never published. But as the other species mentioned by Walter were also there, and correctly named, it was evident that the *S. lutea* of his herbarium must be the *S. minor* of his flora, the reason for the change of name probably being that there is another species with yellow flowers (*S. flava* L.), which is a much larger plant. *S. minor* and *S. variolaris* were rightly considered synonymous by Elliott and several other authors of that period, but for some reason their identity has been doubted by some later authors.

I have no additional notes on this species at the present writing, except that it seems to be the most widely distributed species of *Sarracenia* in the coastal plain of Georgia. It grows in company with *S. flava*, *S. rubra* and *S. psittacina*, as well as in many places where none of the other species are present. It is represented by my numbers 678, from Coffee County, September 21, 1900, and 854, from Bulloch County, June 10, 1901. I have also seen it in Chatham, Effingham, Emanuel, Tattnall, Sumter, Lee and Thomas Counties, always in moist pine-barrens. It is not known from Alabama, however, and I have not seen it within fifty miles of the Chattahoochee River in Georgia.

Sarracenia flava × minor

On June 10 I collected in moist pine-barrens in Bulloch County a single specimen of a curious plant which must be regarded as a hybrid between *Sarracenia flava* and *S. minor*. It consisted of a short horizontal rootstock, like that of most species of the genus, bearing a single erect leaf which seems in every way exactly intermediate between those of the two supposed parents. It was yellowish green, with the hood horizontal (ascending in *S. flava*, deflexed — though horizontal when pressed — in *S. minor*), pubescent and reticulated with reddish veins beneath. The dimensions of the pressed leaf are: length of tube, 34 cm.; diameter at throat, 5 cm.; length of hood, 6 cm.; wing, 5 mm. wide at the middle. This specimen (no. 855) is now in the U. S. National Herbarium.

Where I collected it both of the supposed parents (as well as *S. rubra*, which, however, could have had nothing to do with it) were growing in the immediate vicinity.

It is a curious fact that although there are numerous hybrid Sarracenias in cultivation,* with almost every possible combination of parentage, apparently none has yet been artificially produced between these two yellow-flowered species.

SARRACENIA CATESBAEI Ell. Bot. S. C. & Ga. **2**: 11. 1821

S. flava Catesbaei Mohr, Bull. Torrey Club, **24**: 23. 1897.

There seems to be considerable mystery still surrounding this plant, and the following notes may serve to throw some light on the subject. Elliott described the species from specimens collected by Dr. James Macbride in Chesterfield district (now county), in South Carolina (near the edge of the coastal plain), but states that these specimens are exactly similar to one of the figures on Plate 69 of the second volume of Catesby's "Natural History of Carolina." This, however, should perhaps not be taken too literally, for the figure referred to is a poor one and does not accurately represent any known species; but it most resembles the plant which is now usually accepted as *S. Catesbaei.* Croom, in his monograph of the genus,† states that he has seen Elliott's specimen and was unable to distinguish it from *S. flava.* Most subsequent authors seem to have accepted this view until Dr. Mohr revived *Catesbaei* as a variety in 1897, assigning the name to specimens collected on Lookout Mountain, in DeKalb County, Alabama. In his Plant Life of Alabama it is restored to specific rank. ‡

Last summer, on July 8, I collected in a boggy place southeast of Americus some specimens (no. 1021), which seem to represent this species, intimately associated with *S. rubra* and *S. Drummondii.* It was immediately recognized as a plant which I had seen six years previously in a similar locality about a mile away, where it was associated with the same two species. At that time (1895) the possibility of finding a species not in the standard text-books had never occurred to me, and I referred it to one of the other species. In thinking over the matter a few years later I came to the conclusion that it must be a hybrid between the two species associated with it, but last summer I was convinced that this could not be the case, as the resemblance of *S. Catesbaei* to *S. rubra* is rather remote, and it has some characters not possessed by either of the other two. Elliott says of *S. Catesbaei* that it can be connected with no other species than *S. flava;* but I have noticed a very close and probably hitherto unsuspected relationship between *S. Catesbaei* and *S. Drummondii.* The leaves of these two are of almost exactly the same size and shape, differing principally in coloring, and I fancied that I could almost detect an intergradation between them, for many of the leaves of *S. Catesbaei* had the upper parts of the leaves faintly white-spotted, like those of *S. Drummondii* but in lesser degree. The inner surface of the hood was also pubescent with stiff reflexed hairs, as in *S. Drummondii.* But all had the iridescent purple spot in the throat, a character which is shared only with *S. flava.* If my plant was a hybrid, *S. flava* could hardly be one of its parents, for that species is not known to occur within 27 miles of this place (and in all my travels in Georgia I have never yet seen it west of the Flint River, though it is abundant east of there).

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* See Nicholson, Dict. Gard., and Bailey, Cycl. Am. Hort.

† Ann. Lyc. N. Y. **4**: 104. 1836.

‡ Contr. U. S. Nat. Herb. **6**: 531. 1901.

If the flowers of my plant could be obtained its affinities would be better known, but strangely enough, I have never been able to find the slightest traces of flower or fruit on it. The flowers of this species seem to be very rare. Catesby figures two flowers with yellow petals on the plate cited by Elliott, but these probably belong with the other leaf figured on the same plate, which is a leaf of *S. minor.* Elliott says the flowers of *S. Catesbaei* are unknown to him. In the herbarium of Columbia University there are several very doubtful specimens labeled *S. Catesbaei*, but these are either without flowers or the flowers are detached and may not have been collected with the leaves, and besides they are so old that their color is lost.

Dr. Mohr says of *S. Catesbaei*: "Flowers yellow," but the specimens in his herbarium have no flowers. One of them is like mine, except for being smaller (as might be expected from the elevation at which it grew, 2,000 feet), but the other one so labeled looks more like *S. flava*, and it is possible that both species occur together on Lookout Mountain. The only flowering specimen of *S. Catesbaei* I have seen was collected at the same place by Professor A. Ruth in July, 1898 (no. 253).

But even without flowers *S. Catesbaei* seems to be sufficiently distinct from the other six species (all of which I have often seen in the field), which are often found sterile also (especially the two large ones, *S. flava* and *S. Drummondii*), whether on account of immaturity or unfavorable conditions I do not know.

Further observations of this species in the field, especially in the vicinity of Elliott's type-locality, are much to be desired.

CRATAEGUS CONTRITA Beadle, Biltmore Bot. Stud. **1**: 61. 1902

Collected in the dry deciduous woods about half a mile north of Whigham, on the Lafayette clay at 275 feet altitude, August 10 (no. 1184). The underlying formation here is the Chattahoochee (Upper Oligocene), the same as at the type-locality of this species, which happens to be also the type-locality of the formation.

CRATAEGUS INSIDIOSA Beadle, Biltmore Bot. Stud. **1**: 94. 1902

Collected in dry red clay soil among the hills a few miles northwest of Americus, July 30 (no. 1143). This species and the preceding have been identified for me by Mr. Beadle.

PRUNUS CUTHBERTII Small, Bull. Torrey Club, **28**: 290. 1901

Collected on the steep rocky slopes of the Pine Mountains, at 800 feet altitude, in Upson and Meriwether Counties, August 28 and 29 (nos. 1261 and 1267). Recently reported from Warm Springs in the latter county by Mr. C. L. Boynton.* This species is very different in aspect from some of its relatives, and in winter would hardly be taken for a *Prunus* at all. It is a small straggling tree with short crooked branches and rough bark not unlike that of a *Diospyros*. It seems to be closely related to *P. Alabamensis* Mohr.

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* Biltmore Bot. Stud. **1**: 145. 1902.

This is probably the same species found by Dr. Mohr on the mountains of Clay and Talladega Counties, Alabama, and referred by him to *P. serotina neomontana* Sudw., for his description * (written of course before *P. Cuthbertii* was published) exactly fits my specimens from the corresponding portion of Georgia.

KRAMERIA SECUNDIFLORA DC. (*K. lanceolata* Torr.)

Collected on the sand-hills of Big Lott's Creek, Bulloch County, June 27 (no. 971), and seen the next day in similar situations in Emanuel County, near the rosemary sand-hills. This species has not to my knowledge been reported from Georgia before, or from any adjacent state except Florida. In Bulloch County it is known as "sand-spur," a name which in Southwest Georgia seems to be applied exclusively to *Cenchrus echinatus*. But I found to my surprise that no species of *Cenchrus* seems to be known in the upper part of Bulloch County, and the farmers there are to be considered fortunate in not having made the acquaintance of these pests.

BAPTISIA PERFOLIATA (L.) R. Br.

A common and conspicuous inhabitant of the dry pine-barrens of Bulloch and other counties in the eastern part of Georgia. Collected along the railroad at Butts, Emanuel County, June 6 (no. 802). It has rather a restricted range, being known only from South Carolina and Georgia and probably not occurring west of the Ocmulgee River. The westernmost point at which I have seen it is in Montgomery County.

This species has several peculiarities which have never been described, though they are doubtless well known to the few botanists who have collected it. Its most striking feature is that the perfoliate leaves on the almost horizontal widely spreading branches are all placed vertically, exposing both surfaces equally to the sun and giving the plant a most striking appearance. The phyllotaxy is even more peculiar, the leaves being arranged very nearly in a single row on each branch, with the midribs all pointing toward the zenith. Strictly speaking, they alternate in two rows, with an angular divergence of 15 or 20 degrees between them, instead of 180° as in most cases of two-ranked leaves. These peculiarities are shared by no other species of *Baptisia*, and it is not surprising that this one was made the type of a new genus by Rafinesque.

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* Contr. U. S. Nat. Herb. **6**: 62. 1901.

MEIBOMIA PAUCIFLORA (Nutt.) Kuntze

Collected in rich shady woods near Chokee Creek, Sumter County, on the morning of July 25 (no. 1114). This species differs considerably from its relatives in its flowers. The corollas are not only pure white, as is hinted in the Illustrated Flora and Dr. Britton's Manual, but also more regular than in the other species. The two lower petals instead of being united into a keel are widely diverging, as are the very similar wing-petals. The corolla is therefore hardly papilionaceous, and almost the only evidence of irregularity about it is the larger size of the standard, which is three or four times as broad as the other petals. Most descriptions say nothing about the color of the petals of this species, but Mr. T. H. Kearney and Professor A. Ruth, who have collected it in Tennessee, inform me that their experience has been the same as mine in this respect.

This may perhaps be considered the most primitive species in the genus. In its other characters besides those mentioned it resembles very much its near relative *M. grandiflora* (Walt.) Kuntze, which was found intimately associated with it and collected at the same time (no. 1115).

EUPHORBIA ERIOGONOIDES Small, Bull. Torrey Club, **25**: 614. 1898

In rather dry pine-barrens, Bulloch County, June 10 (no. 846); not common. Previously known only from McIntosh County, where Dr. Small discovered it in 1895. My specimens are less branched than his, but otherwise identical.

HELIANTHEMUM ROSMARINIFOLIUM Pursh

This long neglected (and perhaps not yet very well known) plant seems to be the most abundant species in the vicinity of Millen, growing in dry sandy soil, where I collected it on June 5, (no. 759), at which time it was not yet in flower. Mr. A. H. Curtiss collected it five weeks later at Oliver, 33 miles farther down the Ogeechee River and Central R. R., (no. 6838, distributed as

H. capitatum Nutt.), and on his labels remarks: "In eastern Georgia covering hundreds of acres of old fields as densely as a sowed crop." This is equally true around Millen. It is also more or less abundant along roadsides in the upper part of Bulloch County, where I collected it in flower on the morning of July 1 (no. 986). The original specimens, collected by Enslen, probably came from somewhere in this part of the state. *H. rosmarinifolium* never has the appearance of a native, but seems to be a strictly ruderal plant, and I have never seen it a member of a perfectly natural plant-community. It probably belongs to the considerable class of native weeds, like *Phytolacca decandra*, *Ambrosia artemisiæfolia* and *Eupatorium compositifolium*.

OSMANTHUS AMERICANA (L.) B. & H.

This species has hitherto been supposed to be confined to the immediate vicinity of the coast. But on July 19 I found it in some abundance in dry woods south of Omaha, which is 125 miles inland and probably about 300 feet above sea-level. Only a few of the specimens had fruit on them, however. It also grows on the rosemary sandhills in Emanuel County, on the sandy banks of the Flint River in Sumter County and of Muckalee and Kinchafoonee Creeks in Lee, and in Decatur County near Whigham, as well as on Tybee Island on the coast. It is usually sterile and therefore likely to be overlooked.

SABBATIA FOLIOSA Fernald, Bot. Gaz. **33**: 155. 21 F 1902

Collected in the swamp of Big Lott's Creek, Bulloch County, June 27 (no. 964), and on the shore of a small pond in Decatur County, August 12 (no. 1196). Both numbers have been examined and identified by Mr. Fernald. Seen also at several other points in Bulloch, Emanuel, Tattnall, Montgomery, Telfair, Dodge, Wilcox, Dooly, Thomas and Decatur counties. Mr. Fernald cites specimens of this species only from South Carolina and Florida. It seems to occur also in Alabama, for Dr. Mohr's specimens from Vinegar Bend, Washington County, mentioned in his Plant Life of Alabama as *S. dodecandra*, are good *S. foliosa*. Much of the southern material which has passed as *S. dodecandra* will probably turn out to be the latter species. Mr. Fernald informs me that there are no authentic specimens of the former in the Gray Herbarium from farther south than North Carolina.

The two species are very closely related, differing perhaps in habitat as much as in any other way. *S. dodecandra* seems to be mostly a maritime plant, while the usual home of *S. foliosa* is in creek and river swamps. *S. foliosa* seems to represent one extreme of the *dodecandra* group, of which *S. decandra* is the other.

ASCLEPIAS HUMISTRATA Walt. (*A. amplexicaulis* Michx., not J. E. Smith)

Grows sparingly in dry pine-barrens and on sand-hills in Bulloch County (no. 833, June 10), also seen in Effingham and Stewart counties, always on the Columbia formation. This is another species which seems never to have been completely described. Its glaucous fleshy leaves are so twisted at their points of insertion on the decumbent branches that they lie in vertical planes, giving the plant a very different appearance from any of its Eastern relatives, if not from all other species of the genus. The leaves are practically alike on both surfaces, and their vertical position is of course an example of a well-known adaptation for protection against excessive transpiration. The phyllotaxy of this species is also peculiar, the successive pairs of leaves being not decussate but parallel, analogous to the case of *Baptisia perfoliata* already mentioned.

Asclepias rubra laurifolia (Michx.)

A. laurifolia Michx. Fl. Bor. Am. **1**: 117. 1803.

Differs from *A. rubra* L., in the shape of the leaves, which are lanceolate from a cordate or somewhat hastate subsessile base, tapering uniformly to the apex, or the upper ones narrowed at the base.

Collected in low grounds near Muckalee Creek, Americus, July 29 (no. 1128). Accompanied by *A. lanceolata* Walt. (no. 1127), which it much resembles. Also found in former years in several similar localities within a few miles of Americus, but apparently quite rare, as I have never seen more than two or three individuals at one time.

Asclepias laurifolia Michx. has usually been regarded as identical with *A. rubra* L., but my specimens and others which I have seen (mostly from Georgia), agree very well with Michaux's description and are easily distinguished from *A. rubra*, a plant of more northern range, by the shape of the leaves, which appears to be quite constant. But as this is about the only difference, it seems best to treat Michaux's plant as a variety of *A. rubra*. This may possibly have been done before, but it would be impossible to ascertain this without wading through a great mass of literature. Michaux himself did not contrast the two plants, as he did not mention *A. rubra*. Miss Vail, who has seen his type specimen, which was found "secus amnem Althamaha, in Georgia," says that my specimens resemble it very closely. In the Columbia University Herbarium are specimens of the same plant collected in Georgia by Dr. Boykin and Dr. Chapman (without definite locality), and in Louisiana by Dr. Hale.

NAMA OVATA (Nutt.) Britton. (*Hydrolea ovata* Nutt.)

Collected in shallow water in the Slough near Camilla, Mitchell County, August 8 (no. 1170). I know of no other definite station in Georgia for this species, which is more frequent farther west. It is remarkable for being one of the few aquatic or semi-aquatic plants which are both pubescent and spiny. The spines are sufficiently numerous to make collecting disagreeable when one has to wade in after it barefooted.

COLLINSONIA TUBEROSA Michx.

In rich shady woods on the north side of a bluff of Oostanaula shale east of Dalton, Whitfield County, at 720 feet altitude, September 7 (no. 1287). Has very much the babit of *Phryma Leptostachya*, which grows with it, and its flowers have almost exactly the same odor as those of *Dicerandra odoratissima*. This *Collinsonia* seems to be quite rare, but it is imperfectly understood and its nomenclature is somewhat uncertain.

LINARIA FLORIDANA Chapm.

Collected on the rosemary sand-hills of Emanuel County, June 28 (no. 976); evidently long past flowering, and with over-ripe capsules. Previously known only from drifting sands along the Gulf coast.

PLANTAGO SPARSIFLORA Michx.

Seen only in rather dry pine-barrens about two miles south of Smithville, Lee County, where I collected it on the morning of August 3 (no. 1163). This species has much the appearance of some Melanthaceous plant, for which I mistook it at first glance. It seems to be very rare. There are no specimens of it in the U. S. National Herbarium or that of the New York Botanical Garden besides my own, but in the former there are two specimens so labeled, one from Illinois and the other from Kansas, which are something entirely different. The label of one of them bears a note to a effect that the capsules are 5-seeded, and the other one is similarly noted to have 6-seeded capsules; while in *P. sparsiflora* they are 2-seeded.

In the Columbia University Herbarium are two old and imperfect but unmistakable specimens of *P. sparsiflora*, one from North Carolina and one from South Carolina, as well as a very doubtful specimen from Louisiana and one from Illinois similar to those in the National Herbarium. All these western specimens are annual, while *P. sparsiflora* is perennial from a stout rootstook. Just what the western plant represents is not clear. It may be a form of *P. Virginica*, or perhaps Michaux's *P. Kentuckensis*, a species which seems never to have been recognized. *P. sparsiflora* is credited to Illinois in Britton and Brown's Illustrated Flora, doubtless on the basis of the specimens just mentioned, but it would be indeed remarkable if a species should occur both in Georgia and Illinois without being known from intermediate stations. The true *P. sparsiflora* is known only from the coastal plain of Georgia and the Carolinas, which is about the range given by the Michaux. My specimens, which were probably the first collected for many years, agree perfectly with the original description and most of the later ones.

VIBURNUM NITIDUM Ait. Hort. Kew. **1**: 371. 1789

V. nudum β angustifolium Torr. & Gray, Fl. N. Am. **2**: 14. 1841.

Collected in the swamp of a small pine-barren stream, Bulloch County, June 8 (no. 831), in fruit. This species does not seem to have been recognized by most recent authors, but my attention was called to it by a description in Dr. Mohr's Plant Life of Alabama,* which agrees very well with my specimens. It is very close to *V. nudum*, but can be distinguished in the field without much difficulty. *V. nudum* was collected near the same place two days later (no. 842).

VERNONIA MAXIMA Small, Bull. Torrey Club, **27**: 280. 1900

Abundant on the muddy banks of Mill Creek about two miles east of Dalton, Whitfield County, where I collected it on September 7 (no. 1292). Not previously reported from Georgia.

CACALIA SULCATA Fernald, Bot. Gaz. **33**: 157. 21 F 1902

I have known this species since August 22, 1896, when I first collected it in a sandy bog southeast of Americus, twelve miles from the type-locality given by Mr. Fernald. I have specimens collected at the same place August 20, 1897, and on the same date in 1900 (no. 435). This locality is especially characterized by the presence of *Juncus trigonocarpus* and *Sarracenia Drummondii.* I was never able to refer my specimens to any described species until I saw Mr. Fernald's description, which I immediately recognized as belonging to my plant. I have not seen any of the type material (Curtiss's no. 6884A, from Smithville, Lee County, Ga., August 26, 1901), the only specimen of it distributed by Mr. Curtiss being in the Gray Herbarium, but Mr. Fernald has compared one of my specimens with the type and pronounces them identical.†

This species of course belongs to the genus *Mesadenia* Raf., but Mr. Fernald does not consider *Mesadenia* distinct from *Cacalia*, and as I have not sufficient knowledge of these plants to disagree with him, I refrain from changing the name.

COLLEGE POINT, N. Y.

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* Contr. U. S. Nat. Herb. **6**: 744. 1901.

† I have recently (October, 1902) seen a specimen of the same thing collected in Lee Co., Aug. 20, 1894, by the late Mrs. Sarah Thompson, of Smithville.

A List of the Ferns of Texas

By B. F. Bush

It is now twenty years since Davenport published his "Distribution of ferns in the United States" * in which he gives a very good idea of the distribution of the species then known. In this list he assigns to every state the species known to him to occur in it, and to the state of Texas accredits thirty-five species, one of which number proves to be a duplication, leaving but thirty-four members of this interesting group of plants then known to have been found in the state.

During the twenty years that have passed since Davenport prepared his list, much interest has been taken in the study of ferns, and there has been great activity in collecting them, which has brought to light many species and varieties not previously known to occur in North America, and also a large number of newly described ones; and has added many to the known number in states but little explored. The state of Texas, by its immense area and its extremely diversified topography, with deep swamps in the east and the southeast, rich rocky woods in the northeast, wooded coasts in the south and southwest, and high mountains in the west and northwest, is adapted to a great variety of fern-life. On account of the vast territory embraced, which was not inhabited by white people or was but sparsely settled, the utter lack of railroads, the inaccessibility of various regions, and the small number of collectors in the state, little was known of its fern flora previous to 1860, and not very much when Mr. Davenport prepared his list in 1883.

But the later collections, especially those of Nealley in western Texas, of Jermy in southern Texas, and of Reverchon in eastern, western and central Texas, and my own in southern and southeastern Texas, have done much to increase our knowledge of the number and distribution of the ferns of the state, and critical study of several genera by Professor Underwood, Mrs. Britton and others has brought out additional species.

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* Proc. Am. Phil. Soc. **20**: 605–612. 1883.

Having collected a number of ferns in Texas myself and been instrumental in the discovery of several hitherto unreported species by mentioning to Mr. Reverchon certain others noticed while passing through the eastern part of the state, I have prepared the following list, with some remarks upon the species. I have not seen a complete set of Nealley's collection of Texas ferns, being able to examine only those in the herbarium of the Missouri Botanical Garden and a few in Mr. Reverchon's herbarium ; Mr. Reverchon has sent me a beautiful series obtained by him in the state, comprising about thirty species, a set of which has been deposited in the herbarium of the Missouri Botanical Garden ; and Professor Trelease has lately acquired for the same collection all of the Texas ferns collected by Mr. Jermy.

The number of ferns now known to occur within the state is fifty-nine, as compared with thirty-four in 1883, and from sixteenth place on the list in representation of species, Texas has risen to the second or possibly first place in the list, having more species than were credited to New York by Davenport in 1883. The chief sources drawn upon for this paper are the collections of Nealley, Reverchon, Jermy and myself, which are preserved in the herbarium of the Missouri Botanical Garden and which I was able to examine through the kindness of Professor William Trelease.

I have also consulted Davenport's paper, as mentioned above, Coulter's Flora of Western Texas, Britton & Brown's Illustrated Flora, Underwood's Our Native Ferns, 1st and 6th editions, the Fern Bulletin, and the various revisions by Mrs. Britton and Professor Underwood.*

That the list here presented comprises all the species of ferns of Texas is not very probable, as future researches in the extreme southern and eastern portions of the state will doubtless disclose several more species.

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* Since this paper was prepared one by Mr. Reverchon on the Fern Flora of Texas has appeared in the Fern Bulletin (11 : 33–38. Ap 1903), but this has added to the list only two species, *Ophioglossum pusillum* and *Dryopteris Floridana*, both reported by J. M. Fetherolf from Newton County.

OPHIOGLOSSUM L.

OPHIOGLOSSUM VULGATUM L.

In low meadows, fields and sandy swamps.

SPECIMENS EXAMINED: On the Sabine, Big Sandy, Upshur County, *Reverchon* 2796, April 10, 1902.

OPHIOGLOSSUM ENGELMANNI Prantl

Ophioglossum vulgatum authors in part, not L.

In rocky barrens and glades.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 1180, 3379, 1876; 3380, 3381, May 4, 1900; *Bush* 660, 661, May 8, 1900; New Braunfels, Comal County, *Lindheimer* 414, May, 1850; Houston, Harris County, *Hall* 858, April 16, 1871; Comanche Spring, Pecos County, *Lindheimer* 53, May, 1849.

OPHIOGLOSSUM PUSILLUM Nutt.

No specimens seen, but it has been collected recently in Newton County by *Fetherolf.*

OPHIOGLOSSUM CROTALOPHOROIDES Walt.

Uncommon; in sandy woods and fields.

SPECIMENS EXAMINED: Houston, Harris County, *Hall*, March, 1872.

BOTRYCHIUM Sw.

Two species known to occur in Texas; a third, *B. biternatum* (Lam.) Underwood, is to be looked for in the eastern part of the state.

BOTRYCHIUM OBLIQUUM Muhl.

Botrychium ternatum American authors, not Sw. (which is a Japanese species).

In meadows, open sandy woods, and sandy places in swamps.

No specimens of this species have been seen from Texas, and is included in this list on the authority of Professor Underwood, Bull. Torrey Club, **25**: 533. 1898.

BOTRYCHIUM VIRGINIANUM (L.) Sw.

In rich woods in shady places.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 3382, April 19, 1874; 1181, May, 1875; Grand Saline, Van Zandt

County, *Reverchon* 1900; Big Sandy, Upshur County, *Reverchon* 3361, April 10, 1902.

ORNITHOPTERIS Bernh.

ORNITHOPTERIS MEXICANA (Klotzsch) Underwood

Anemia Mexicana Klotzsch.

On shaded rocks and clefts of rocks in mountainous regions.

SPECIMENS EXAMINED: Upper Hondo, Bandera County, *Reverchon* 1627, June, 1885; Uvalde County, *Reverchon* 1627, 1885; *Mrs. Young*, date of collection not given, but probably about 1876; Medina County, *Reverchon* 1627, 1885; western Texas, *Lindheimer*, July, 1847, 1849–51; *Wright*, October, 1849; New Braunfels, Comal County, *Wright*, November, 1849; southern Texas, *Lindheimer*, 1849–51.

OSMUNDA L.

OSMUNDA REGALIS L.

In low wet woods and meadows.

SPECIMENS EXAMINED: Mineola, Wood County, *Reverchon*, October, 1900; Marshall, Harrison County, *Bush* 986, October 8, 1901; no locality, *Wright*, date of collection not given, but probably about 1849 or 1850; Troupe, Smith County, *Reverchon* 2800, May 8, 1902.

It is a little remarkable that Mr. Davenport neglected to give this species for Texas in his paper, as it was collected and distributed so many years ago by Wright.

OSMUNDA CINNAMOMEA L.

In low rich woods and swamps.

SPECIMENS EXAMINED: Tyler, Smith County, *Reverchon* 1847, 2333, September 20, 1900; Lindale, Smith County, *Reverchon* 2333, May, 1901; 3383, June 23, 1901; Big Sandy, Upshur County, *Reverchon* 3384, May 27, 1901; Marshall, Harrison County, *Bush* 987, October 8, 1901.

POLYPODIUM L.

POLYPODIUM POLYPODIOIDES (L.) Hitchcock

Polypodium incanum Sw.

Marginaria incana Presl, Tent. Pterid. 188. 1836.

On trees, and often on mossy banks and on rocks.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 1182, 3389, August, 1876; Brazos County, *Reverchon*, 1880; Houston, Harris County, *Hall*, date of collection not given; *Ravenel*, date of collection not given; Columbia, Brazoria County, *Bush* 175, 1899; 152, April 24, 1900; 917, September 26, 1901; Marshall, Harrison County, *Bush* 629, August 8, 1901; 1008, October 9, 1901; Buffalo Bayou and Bray's Bayou, *Lindheimer* 4, 1839; New Braunfels, Comal County, *Wright*, November, 1849.

BOMMERIA Fourn.

BOMMERIA HISPIDA (Mett.) Underwood, Bull. Torrey Club, **29**: 633. 1902

Gymnogramme hispida Mett.

Gymnopterus hispida Underwood.

Rare; on exposed rocks in mountainous regions.

SPECIMENS EXAMINED: Chenate Mountains, Presidio County, *Nealley* 889, date of collection not given (1887–89); *Havard* 3390, 1880; western Texas, *Wright*, date of collection not given, but probably about 1849 or 1850.

NOTHOLAENA R. Br.

Nine species are known to occur in Texas, and with *Cheilanthes*, form the characteristic fern flora of the state. The genus is largely represented in Mexico and adjacent territory, and it is therefore probable that, in the extreme western and southwestern portions of the state, several other species will be discovered.

NOTHOLAENA SINUATA (Sw.) Kaulf.

On exposed rocks in mountainous regions.

SPECIMENS EXAMINED: San Geronimo Creek, Medina County, *Reverchon* 1184, June, 1885; San Angelo, Tom Green County, *Reverchon*, May, 1885; House Mountain, Mason County, *Reverchon*, May, 1885; Upper Concho, Tom Green County, *Reverchon*, April, 1882; southwestern Texas, *Reverchon*, May, 1885; mouth of the Rio Pecos, on the Rio Grande, Val Verde County, *Havard* 5, 16, 1880; Kiowa Peak, *Boll*, 1879; Chenate Mountains, Presidio County, *Nealley* 895, date of collection not given (1887–89); Uvalde Cañon, *Mrs. Young*, date of collection not given, but probably about 1876; Crab Apple, Gillespie County, *Jermy*, date of collection not given; southern Texas, *Lindheimer*, 1849–51; western Texas, *Lindheimer*, June, 1845; *Wright* 814, 815, October, 1849; New Braunfels, *Lindheimer*, July, 1847; *Wright*, 1850.

NOTHOLAENA FERRUGINEA Desv.

On rocks in mountainous regions.

SPECIMENS EXAMINED: Chenate Mountains, Presidio County, *Havard* 4, 6, 1219, 3398, 1880; *Nealley* 891, date of collection not given (1887–89); southern Texas, *Lindheimer*, 1849–51.

NOTHOLAENA ASCHENBORNIANA Klotzsch

Very rare; on exposed rocks in mountainous regions.

No specimens of this species have been seen, but it was collected in Texas many years ago by *Trecul* and *Drummond;* localities and dates of collections not ascertained. Specimens of this were distributed by Drummond.

NOTHOLAENA CANDIDA (M. & G.) Hook.

On exposed rocks in mountainous regions.

SPECIMENS EXAMINED: Cañon of the Sabinal, Uvalde County, *Reverchon* 1626, June, 1885; Blanco County, *Reverchon*, 1885; Uvalde Cañon, *Mrs. Young*, date of collection not given, but probably about 1876; Cedar Mountain, Gillespie County, *Jermy*, date of collection not given; western Texas, *Wright* 820, October, 1849.

NOTHOLAENA HOOKERI Eaton

On exposed rocks and in clefts of rocks in granite formations.

SPECIMENS EXAMINED: House Mountain, Mason County, *Reverchon* 1218, May, 1885; Llano County, *Reverchon*, May, 1885; Chenate Mountains, Presidio County, *Havard* 3, 1218, 3395, 1880; Limpia Cañon and Chenate Mountains, Presidio County, *Nealley* 890, 893, date of collection not given (1887–89); western Texas, *Wright* 821, October, 1849.

NOTHOLAENA GRAYI Davenport

On exposed rocks in granitic formations.

SPECIMENS EXAMINED: Chenate Mountains, Presidio County, *Havard* 7, 1220, 3397, 1880; Limpia Cañon and Chenate Mountains, Presidio County, *Nealley* 892, date of collection not given (1887–89).

NOTHOLAENA SCHAFFNERI (Fourn.) Underwood

Aleuritopteris Schaffneri Fourn.

Notholaena Nealleyi Seaton.

Rare; on exposed rocks in granitic formations.

SPECIMENS EXAMINED: Chenate Mountains, Presidio County, *Nealley* 894, date of collection not given (1887–89).

NOTHOLAENA DEALBATA (Pursh) Kunze

Notholaena nivea dealbata Davenport.

On faces of calcareous rocks and bluffs.

SPECIMENS EXAMINED: On the Brazos River, Palo Pinto County, *Reverchon* 798, 3396, August 18, 1877; Comanche Peak, Hamilton County, *Reverchon*, April, 1885; on the San Saba, San Saba County, *Reverchon*, 1183, April, 1885; Meridian, Bosque County, *Hasbrouck*, date of collection not given; Austin, Travis County, *Hepperly*, 1880; western Texas, *Lindheimer* 508, 1851.

NOTHOLAENA FENDLERI Kunze

Rare; on exposed rocks in mountainous regions.

No specimens of this species have been seen from Texas and it is included in this list on the authority of Eaton in his "Ferns of North America."

ADIANTUM L.

Two species known to occur in Texas; one other, *A. pedatum* L., probably occurs in the northern part of the state.

ADIANTUM CAPILLUS-VENERIS L.

On wet limestone rocks along river banks, and about springs in rocks.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 1189, 3404, August, 1876; Crockett County, *Reverchon*, 1885; Austin, Travis County, *Hall*, date of collection not given, but probably about 1871 or 1872; San Antonio, *Mrs. Young*, date of collection not given, but probably about 1876; *Bush* 834, September 18, 1901; Crab Apple, Gillespie County, *Jermy*, date of collection not given; Kerrville, Kerr County, *Heller* 1939, July 2, 1894; southern Texas, *Lindheimer*, 1849–51.

ADIANTUM TRICHOLEPIS Fee

Rare; on exposed rocks in mountainous regions.

No specimens of this species have been seen from Texas, but it was collected at the mouth of the Pecos, Val Verde County, by *Bigelow*, date of collection not ascertained.

PTERIDIUM Scop.

PTERIDIUM AQUILINUM (L.) Kuhn

Pteris aquilina L.

In dry open rocky and sandy woods.

SPECIMENS EXAMINED: Houston, Harris County, *Hall*, date of collection not given, but probably 1871 or 1872.

PTERIDIUM AQUILINUM PSEUDOCAUDATUM Clute, Fern Bull. **8**: 39. 1900, as syn.

Pteris aquilina caudata authors, in part, not Hooker, Sp. Fil. **2**: 196. 1858.

In open sandy woods and fields.

SPECIMENS EXAMINED: Big Sandy, Upshur County, *Reverchon* 1194, 3404, May 27, 1901; Silver Lake and Gladewater, Gregg County, *Reverchon* 3403, May 22, 1900; Marshall, Harrison County, *Bush* 628, August 8, 1901; 1035, October 10, 1901; Houston, Harris County, *Lindheimer*, September, 1842.

PTERIDIUM CAUDATUM (L.) Maxon, Proc. U. S. Nat. Mus. **23**: 631. 4 My 1901

Pteris caudata L.

Pteris aquilina caudata Hooker.

Pteridium aquilinum caudatum Kuhn.

In deep swamps near the coast.

No specimens of this species have been seen from the state, and is included in the list of Texas ferns on the authority of Clute (Fern Bulletin, **8**: 38. 1900) and of Underwood and Eaton.

CHEILANTHES Sw.

The largest genus of ferns in the state, forming the most conspicuous group of the Pteridophyta of Texas. The species are numerous in Mexico and adjacent territory, and it is probable that others will be discovered in Texas.

CHEILANTHES WRIGHTII Hooker

Rare; on exposed rocks in granitic formations.

SPECIMENS EXAMINED: Limpia Cañon, Presidio County, *Nealley* 899, date of collection not given (1887–89); western Texas, *Wright* 823, October, 1849.

CHEILANTHES MICROPHYLLA Sw.

On exposed rocks in mountainous regions.

SPECIMENS EXAMINED: Limpia Cañon, Presidio County, *Nealley* 897, date of collection not given (1887–89); Uvalde Cañon, *Mrs. Young*, date of collection not given, but probably about 1876.

CHEILANTHES ALABAMENSIS (Buckley) Kunze

On shaded rocks along streams.

SPECIMENS EXAMINED: Indian Creek, Brown County, *Reverchon* 1188, 3394, April, 1882; Upper Guadalupe, Kendall County, *Reverchon* 1188, June, 1885; San Antonio, Bexar County, *Boll*, May, 1877; *Bush* 852, September 19, 1901; Chenate Mountains, Presidio County, *Havard* 15, 1880; mouth of the Pecos, along the Rio Grande, Val Verde County, *Bigelow*, date of collection not given; Austin, Travis County, *Hall*, date of collection not given, but probably about 1871 or 1872; Squaw Creek, Gillespie County, *Jermy*, date of collection not given; Lower Rio Grande, *Schott*, date of collection not given; New Braunfels, *Lindheimer* 310, 1851.

CHEILANTHES LEUCOPODA Link

Rare; on rocks in mountainous regions.

SPECIMENS EXAMINED: Uvalde Cañon, *Mrs. Young*, date of collection not given, but probably about 1876.

CHEILANTHES LANOSA (Michx.) Watt.

Cheilanthes vestita Sw.

On faces of calcareous bluffs.

No specimens of this species have been seen from Texas, and is included on the authority of Britton & Brown's Illustrated Flora.

CHEILANTHES FEEI Moore

Cheilanthes gracilis (Fee) Mett., not Kaulf.

Cheilanthes lanuginosa Nutt.

On faces of calcareous rocks and bluffs.

SPECIMENS EXAMINED: On Sterling Creek, Town Mountain, Tom Green County, *Reverchon* 1186, 3392, April, 1882; Hamilton County, *Reverchon*, April, 1885; Upper Concho, Tom Green County, *Reverchon* 1186, 3394, April, 1882; Amarillo Creek, Armstrong County, *Reverchon* 2799, May 30, 1902; Concho, Tom Green County, *Boll* 1186, April, 1879; western Texas, *Wright* 816, 818, October, 1849.

CHEILANTHES TOMENTOSA Link

In clefts of sandstone, and on granitic formations.

SPECIMENS EXAMINED: House Mountain, Mason County, *Reverchon* 1625, 1882; Brown County, *Reverchon* 1625, May, 1885; Jack County, *Reverchon* 1625, May 1882; Brownwood, Brown County, *Reverchon* 1187, August 10, 1877; Brazos Station, Palo Pinto County, *Reverchon* 1187, May 1, 1882; Graham, Young County, *Reverchon* 3364, October 29, 1902; Chenate Mountains, Presidio County, *Neally* 898, date of collection not given (1887–89); western Texas, *Lindheimer* 442, 743, 1847.

CHEILANTHES EATONI Baker

On exposed rocks in granitic formations.

SPECIMENS EXAMINED: House Mountain, Mason County, *Reverchon* 1625, May, 1885; Llano County, *Reverchon*, May, 1885; Limpia Cañon and Chenate Mountains, Presidio County, *Nealley* 896, date of collection not given (1887–89).

CHEILANTHUS FENDLERI Hook.

Rare; on exposed rocks in mountainous regions.

No specimens of this species have been seen from Texas, but it was collected in the western part of the state many years ago by *Fendler*, locality and date of collection not ascertained.

CHEILANTHES MYRIOPHYLLA Desv.

Rare; on rocks in mountainous regions.

No specimens of this species have been seen from Texas, and is included on the authority of Underwood and Maxon.

CHEILANTHES LINDHEIMERI Hook.

On exposed rocks and clefts of rocks in granitic formations.

SPECIMENS EXAMINED: Llano County, *Reverchon* 1624, 1885; Burnett County, *Reverchon* 1624, 1885; House Mountain, Mason County, *Reverchon* 1624, May, 1885; western Texas, *Lindheimer* 441, 744, 1847.

PELLAEA Link

An important genus in the Texas fern flora.

PELLAEA ATROPURPUREA (L.) Link

On rocks along shaded banks and on faces of bluffs.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 1185, May, 1876; west of the Brazos, *Reverchon*, 1880; Mason County, *Reverchon*, 1185, May, 1885; Crab Apple, Gillespie County, *Jermy*, date of collection not given; northwest Texas, *Mary Soulard*, 1883; Austin, Travis County, *Streenwitz*, 1893.

PELLAEA ASPERA (Hook.) Baker

On exposed rocks in granitic formations.

SPECIMENS EXAMINED: On the Upper Hondo, Bandera County, *Reverchon* 3401, June, 1885; San Geronimo Creek, Medina County, *Reverchon* 1629, 3401, June, 1885; San Antonio, Bexar County, *Palmer*, date of collection not given; Chenate Mountains, Presidio County, *Nealley* 900, date of collection not given (1887–89); Uvalde County, *Mrs. Young*, date of collection not given, but probably about 1876.

PELLAEA PULCHELLA (M. & G.) Fee

On exposed rocks in granitic formations in mountainous regions.

SPECIMENS EXAMINED: Chenate Mountains, Presidio County, *Havard* 2, 1217, 3402, September, 1880; Uvalde County, *Mrs. Young*, date of collection not given, but probably 1876; El Paso, El Paso County, *G. R. Vasey*, date of collection not given; western Texas, *Wright* 825, 1849.

PELLAEA TERNIFOLIA (Cav.) Link.

Rare; on exposed rocks in granitic formations.

SPECIMENS EXAMINED: Limpia Cañon, Presidio County, *Nealley* 902, date of collection not given (1887–89).

PELLAEA WRIGHTIANA Hook.

On exposed rocks in granitic formations in mountainous regions.

SPECIMENS EXAMINED: Llano County, *Reverchon* 1216, May and June, 1885; Gillespie County, *Jermy*, date of collection not given; Chenate Mountains, Presidio County, *Havard* 1, September, 1880.

PELLAEA FLEXUOSA (Kaulf.) Link

On shaded rocks along streams.

SPECIMENS EXAMINED: Moon Mountains, San Saba County, *Reverchon* 1628, May, 1885; Llano County, *Reverchon* 1628, May, 1885; Youngblood County, *Jermy*, date of collection not given; Limpia Cañon, Presidio County, *Nealley* 901 (in part), date of collection not given (1887–89); southwestern Texas, *Palmer*, date of collection not given; southern Texas, *Lindheimer*, July, 1846; 1849–51; western Texas, *Wright* 825, 1849.

PELLAEA INTERMEDIA Mett.

Rare; on exposed rocks in granitic formations.

SPECIMENS EXAMINED: Limpia Cañon, Presidio County, *Nealley* 901 (in part), date of collection not given (1887–89).

WOODWARDIA J. E. Smith

WOODWARDIA VIRGINICA (L.) J. E. Smith

In deep wooded swamps.

No specimens of this species have been seen from Texas, but it was collected in the state by *Wright* many years ago, locality and date of collection not ascertained; probably in southeastern Texas in 1849 or 1850.

WOODWARDIA AREOLATA (L.) Moore

Woodwardia angustifolia J. E. Smith.

In deep wooded swamps.

SPECIMENS EXAMINED: Mineola, Wood County, *Reverchon* 1190, October 18, 1900; Big Sandy, Upshur County, *Reverchon* 1190, October 18, 1900; Marshall, Harrison County, *Bush* 988, October 8, 1901.

ASPLENIUM L.

ASPLENIUM PLATYNEURON (L.) Oakes

Asplenium ebeneum Ait.

In rich woods and on hummocks in swamps.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon* 1191, 3306, August, 1876; Mineola, Wood County, *Reverchon*, 1901; College Station, Brazos County, *Reverchon*, date of collection not given; Big Sandy, Upshur County, *Reverchon* 3363, September 16, 1902; Beekville, Panola County, *Reverchon* 3362, October 9, 1902; Houston, Harris County, *Hall*, date of collection not given, but probably about 1871 or 1872; Harrisburg, Harris County, *Joor*, date of collection not given; San Antonio, Bexar County, *Mrs. Young*, date of collection not given, but probably about 1876; Columbia, Brazoria County, *Bush* 99, April 20, 1900; 151, April 24, 1900; 922, September 26, 1901; Houston, Harris County, *Lindheimer*, 1842; southern Texas, *Lindheimer*, 1842.

ASPLENIUM PARVULUM M. & G.

On shaded rocks and faces of bluffs, and on rocky banks.

SPECIMENS EXAMINED: San Geronimo Creek, Medina County, *Reverchon* 1192, May, 1885; Upper Guadalupe, Kendall County, *Reverchon* 3307, May, 1885; San Antonio, Bexar County, *Boll*, May, 1877; Houston, Harris County, *Hall*, date of collection not given, but probably in 1871 or 1872; Gillespie County, *Jermy*, date of collection not given; Chenate Mountains, Presidio County, *Nealley* 903, date of collection not given (1887–89); southern Texas, *Lindheimer*, 1849–51.

ASPLENIUM TRICHOMANES L.

On rocks in hilly and mountainous regions.

No specimens of this species have been seen, and it is included on the authority of Davenport and Maxon.

ATHYRIUM Roth

ATHYRIUM ACROSTICHOIDES (Sw.) Maxon, Fern Bull. **9**: 60. 1901

Asplenium acrostichoides Sw.

Asplenium thelypteroides Michx.

Athyrium thelypteroides Desv.

In low ground and wooded swamps.

Specimens examined: Mineola, Wood County, *Reverchon* 1814, 3508, June 11, 1900.

Athyrium Filix-foemina (L.) Roth, Tent. Fl. Germ. **3**: 65. 1800

Polypodium Filix-foemina L.

Asplenium Filix-foemina Bernh.

In rich shaded woods and in swamps.

Specimens examined: Houston, Harris County, *Engelmann*, August 13, 1878; Marshall, Harrison County, *Bush* 985, October 8, 1901; Texas, *Wright*, locality and date not given, but probably about 1849 or 1850; Mineola, Wood County, *Reverchon* 3569, June 12, 1900; 1814, 2797, July 8, 1902.

DRYOPTERIS Adans.

Dryopteris Thelypteris (L.) A. Gray

In low swampy woods.

Specimens examined: Hempstead, Waller County, *Hall*, date of collection not given, but probably in 1872.

Dryopteris patens (Sw.) O. Kuntze

On hummocks and on logs in deep wooded swamps.

Specimens examined: On the Guadalupe, Kendall County, *Reverchon* 1195, 3388, May and June, 1885; Upper Hondo, Bandera County, *Reverchon*, 1885; on the Llano, Mason County, *Reverchon*, 1885; Lancaster, Dallas County, *Reverchon*, November, 1877; Austin, Travis County, *Boll* 1195, July, 1879; Hockley, Harris County, *Thurow*, date of collection not given; San Antonio, Bexar County, *Heller* 1835, June 9, 1894; *Bush* 816, September 17, 1901; Columbia, Brazoria County, *Bush* 1466, October 12, 1900; 923, September 26, 1901; western Texas, *Lindheimer*, date of collection not given; *Wright*, date of collection not given; southern Texas, *Lindheimer*, 1849–51; New Braunfels, Comal County, *Lindheimer* 742, July, 1847; Houston, Harris County, *Lindheimer*, June, 1842.

Dryopteris Floridana (Hook.) O. Kuntze

No specimens seen, but it has been reported recently from Newton County by *Fetherolf*.

POLYSTICHUM Roth

POLYSTICHUM ACROSTICHOIDES (Michx.) Schott

On rich shaded hillsides and in swampy woods and fields.

SPECIMENS EXAMINED: Mineola, Wood County, *Reverchon* 1813, 3387, June 11, 1900; Gladewater, Gregg County, *Reverchon* 1813, June, 1900; Mineola, Wood County, *Reverchon* 2798, July 9, 1902; Big Sandy, Upshur County, *Reverchon*, September 16, 1902; Marshall, Harrison County, *Bush* 627, August 8, 1901; 1004, October 9, 1901; Houston, Harris County, *Lindheimer*, June, 1842.

PHANEROPHLEBIA Presl

PHANEROPHLEBIA AURICULATA Underwood, Bull. Torrey Club, **26**: 212. 1899

Aspidium juglandifolium in part of recent authors, not Kunze.

Rare; in granitic formations in mountainous regions.

No specimens of this species have been seen, but it was collected at Hueco Tanks, El Paso County, and at Van Horn's Well, Jeff Davis County, by the *Mexican Boundary Survey*.

TECTARIA Cav.

TECTARIA TRIFOLIATA (L.) Cav.

Aspidium trifoliatum Sw.

Rare; on limestone bluffs and on rocks.

SPECIMENS EXAMINED: New Braunfels, Comal County, *Lindheimer*, 1847.

ONOCLEA L.

ONOCLEA SENSIBILIS L.

Along river banks and in swamps.

SPECIMENS EXAMINED: Mineola, Wood County, *Reverchon* 2194, October 19, 1900: Big Sandy, Upshur County, *Reverchon* 1812, October 19, 1900; Marshall, Harrison County, *Bush* 630, August 8, 1901; 1007, October 9, 1901; Houston, Harris County, *Lindheimer*, 1842.

WOODSIA R. Br.

WOODSIA OBTUSA (Spreng.) Torr.

On shaded banks and rocks in rich woods along streams.

SPECIMENS EXAMINED: Dallas, Dallas County, *Reverchon*

1193, 3386, May, 1877; 3385, May 27, 1900; House Mountain, Mason County, *Reverchon*, 1885; Corsicana, Navarro County, *Reverchon* 3365, April 25, 1902; Marshall, Harrison County, *Bush* 1005, October 9, 1901.

WOODSIA MEXICANA Fee

Rare; on exposed rocks in mountainous regions.

No specimens of this species have been seen, and it is included in this list on authority of Davenport and Maxon.

COURTNEY, MO.

Isoetes riparia Canadensis and Isoetes Dodgei

By A. A. Eaton

For a period of nearly seventy years, and from widely separated localities, an *Isoetes* has been collected and variously referred by authors, but always with hesitation and doubt, until 1898, when it was described in the Fern Bulletin as *I. Dodgei*, founded upon specimens from Kingston, N. H., and Vancouver Island, B. C. It is near *I. riparia* in many respects, but differs especially in its more rigid leaves, usually with four bast-bundles, its light-spotted sporangium, and the rather jagged, isolated crests of the gynospores. Noting Dr. Engelmann's rather vague description of *I. riparia Canadensis* in his monograph, specimens of *I. Dodgei* were sent to be compared with that variety, and were pronounced distinct. Through the kindness of Dr. Trelease I have since had an opportunity to examine all of Dr. Engelmann's material of this genus, and have established with little room for doubt that not only are *I. riparia Canadensis* and *I. Dodgei* identical, but that nearly all of Engelmann's so-called *I. riparia* from New England, a part of that from Pennsylvania, and even some specimens referred to *I. Engelmanni*, are that species also.

The cause of confusion doubtless lies in the fact that all of Engelmann's material of this is more or less immature and fragmentary. There appears to be no type-material in his herbarium, for in "Notes and Sketches," **59**: 90, he states that all his specimens, which were poor, were sent to Braun, who said they were "probably of a new species between *I. lacustris* and *I. riparia*." This was from Canada, the place, date and collector not given. We may conjecture, however, that it came from Crow River, collected by Macoun. Engelmann cites two localities for the variety: Cornish, Maine, Chickering, and Crow River, Canada, Macoun. Of the latter he has three plants, all told, of 6–10 leaves, 7.5–10 cm. high. They grew under water and have a starved appearance. According to the label it was found "in rather swift-running water just above the dam at Marmora iron works," etc., J. Macoun, July 18, 1864. The submersed position and early date of collecting account for their appearance. The spores are like those of Kingston plants.

The only representative of the Cornish locality is a single small specimen attached to an exchange label of D. C. Eaton. It was collected in 1859, but the month is not stated. It is also very immature, and grew under water. Engelmann says of this: "The whole plant looks exactly like the Kennebunk plant which I have referred to *Engelmanni borealis*, or perhaps to *Tuckermanni*, but spores differ. Dec. 25th, 1866." Later this was crossed out and "*riparia* var. *Canadensis*" substituted. The same sheet also bears the legend: "No doubt *Braunii:* = the Canada plant, Jan. 11, 1867." The Kennebunk plant referred to is a single small immature plant from the Gray Herbarium, 1867, collector and date not given. The label also bears the name "*riparia* forma ~~minor~~ borealis." In the Gray Herbarium is a specimen from Kennebunk, whose label Mr. Fernald has kindly copied as follows: "*Isoetes Engelmanni* Br., forma minor borealis. Sporis majoribus. Kennebunk. One of the doubtful (perhaps transitional) forms. Will examine again. G. E. 1867." Mr. Fernald conjectures that this was collected by Engelmann himself, but this cannot be, as his specimen is given as "Ex. Hb. Gray."

This completes the list of localities as recognized by Engelmann, but a study of his *I. riparia* from the banks of the Connecticut river, opposite Brattleboro, Vt., Chesterfield or Hinsdale, N. H., shows it to be a more nearly mature form of *I. riparia Canadensis*, although the leaves are covered with confervae and diatoms and soak out so badly that I could not be sure of the bast-bundles. In his "Notes and Sketches," **59**: 89, Engelmann says: "Crests of macrospores short, often scarcely anastomosing: (apparently *I. Braunii*), in others (especially below) almost reticulated; very pale brown sclerenchym cells in sporangium. Macrospores those of *riparia* without doubt," and again: "Why not rather *lacustris?*"

I find among Engelmann's *I. riparia* a sheet whose label bears this legend: "These from the banks of the Lehigh river, on an island near Bethlehem, growing like the Delaware *riparia*, in the sandy mud of the river, among and between stones, July 30, 1866. E. Durand." This is supplemented by another specimen which Engelmann calls "forma *parvula*," the label of which reads:

"On the island above Bethlehem, Pa., bridge, growing between stones and gravel on the banks, always covered with water and at the level of the lowest stage of water in Lehigh river. E. Durand. Oct. 20, 1866." This last, being immature, will be dismissed from further consideration, save to state that Engelmann (Notes and Sketches, **59**: 93) says: "*I. riparia.* Cannot be *Engelmanni* (and is probably not from Bethlehem)."

The former is sketched on the same page under title of *I. paupercula* A. Br., under which name both of these appear in Hb. Engelm. Pencilled notes read: "*I. paupercula* A. Br. in litt., sclerenchym cells on sporangium but very light yellow, not brown. Bast-bundles fully developed, only 2 (Braun says, I think I have seen 3 or even 4). I take it to be *riparia* after repeated investigations which certainly show some bast-bundles in the stiff rigid leaves." This is accompanied by the following note: "A. Braun in litt., April 3, 1867. '*I. paupercula* mihi; doubtful between *riparia* and *Engelmanni* (as Engelmann expressed himself in sending them). A hybrid? Sporangium with pale sclerenchym cells. Macrospores larger, ridges erose, somewhat reticulate below, scarcely differing from *riparia* but with 2 median bast-bundles.'"

One of the first collections of *Isoetes* in America was made by Moser in 1832, in Pennsylvania. A specimen of his collecting is in the Engelmann collection, and is referred by Engelmann to *I. Engelmanni.* It was collected on an island in the Lehigh, probably, as Engelmann's label reads, at Bethlehem. Although rather immature, this is doubtless *I. Canadensis*, as spores are characteristic. The original label belonging to this specimen apparently now adorns a sheet of *I. setacea*, and one written by Engelmann accompanies the specimen.

Finally there is a sheet bearing specimens collected by E. A. Rau, August, 1882, on "shaded banks of Lehigh river, at Bethlehem, Pa." This, to judge from pencil notes, was referred alternately to *I. Engelmanni* and *I. Braunii*, but finally included in the former, where it now appears. Engelmann's notes say: "Very weak bast-bundles, sporangium spotted, macrospores .47–.57 mm., cristate-reticulate, stomata, microspores normally .024 mm., smooth, white." I find some gynospores that reach 700 μ. The androspores mounted dry, the only way in which an idea of their appearance may be had save by considerable manipulation, are characteristic of *I. Canadensis*. Fuller descriptions may be had by reference to the description of *I. Dodgei* (Fern. Bull. **6**: 5. 1898). I can find no difference between these and the submersed form of the Kingston (N. H.) plants.

With material at hand from so many localities it is a matter of no little surprise that Engelmann and Braun did not recognize their identity and specific value.

The species becomes **I. Canadensis,** with the following synonymy:

Isoetes Canadensis (Engelm.) A. Br. Mss.

I. riparia Canadensis Engelm. Trans. Acad. Sci. St. Louis **4**: 383. 1882.

I. Dodgei A. A. Eaton, Fern Bull. **6**: 5. 1898; Fernwort Papers, 15. 1900.

I. lacustris Moser, in herb. 1832. Not L.

I. Canadensis A. Br., in letter to Engelm., 3 Ap 1867.

I. paupercula A. Br., in letter to Engelm., 3 Ap 1867. Not *I. lacustris paupercula* Engelm. Trans. Acad. Sci. St. Louis, **4**: 377. 1882.

I. Engelmanni Engelm. in part. Not A. Br.

I. riparia Engelm. in part.

It has been seen from the following localities: British Columbia: Vancouver Island, *Macoun*. Ontario: Crow River, near Belleville, *Macoun*. Maine: Cornish, *Chickering;* Kennebunk (coll. ?); Peasepond, East Wilton, *Fernald*. New Hampshire: Kingston, *A. A. Eaton;* "Opposite Brattleboro, Vt.," *Frost*. Massachusetts: Paul's Bridge, Dedham, *C. E. Faxon*. Pennsylvania: Point Pleasant, *Best;* Bethlehem, *Durand, Rau, Moser;* Mouth of Tucquan (Lancaster Co.), no collector given, and determination rests on androspores alone (specimen in U. S. Nat. Herb.).

The emersed form, with intricately snarled leaves, is unique and well deserving varietal rank. This being the form from which most of my characters of *I. Dodgei* were drawn, it may well bear the name of **I. Canadensis Dodgei.** It has not been seen from any other locality than Kingston, N. H.

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BULLETIN

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TORREY BOTANICAL CLUB

JULY, 1903

A Preliminary Enumeration of the Grasses of Porto Rico

By GEORGE V. NASH

This enumeration is based mainly upon the material in the herbarium of the New York Botanical Garden. The collections of Heller, Underwood and Griggs, Wilson and Goll are there fully represented, and those of Sintenis partially so. A few species, of which we have not seen specimens, have been admitted upon the authority of monographers. Further explorations of the island must add more species, and it is hoped that this enumeration may serve as a help in such further exploration. That this work may be facilitated, it has been deemed advisable to incorporate analytical keys to the tribes, genera and species. This enumeration credits the island with 10 of the 13 grass tribes, 37 genera, and 75 species and varieties, among them 9 hitherto unknown.

Key to the Tribes

A. Spikelets falling from the pedicel entire, naked or enclosed in bristles or a bur-like involucre, or immersed in the internodes of a readily disarticulating rachis, 1-flowered, or if 2-flowered the lower flower staminate (perfect in *Isachne*) : internodes of the rachilla of the spikelet very short, not measurable.
  Spikelets round or somewhat dorsally compressed : hilum punctiform.
    Flowering scale and palet hyaline, thin, much more delicate in structure than the thick-membranous to coriaceous empty scales.
      Spikelets unisexual. Tribe I. MAYDEAE.

      Spikelets in pairs, one sessile, the other pedicellate, the former perfect, the latter sometimes perfect, often with a staminate flower, or frequently empty, abortive or wanting. Tribe II. ANDROPOGONEAE.
    Flowering scale, at least that of the perfect flower, similar in texture to the empty scales, or frequently thicker and firmer, never hyaline and thin.

[The preceding number of the BULLETIN, Vol. 30, No. 6, for June, 1903 (30 : 319–368), was issued 11 Je 1903.]

Flowering scale and palet membranous.
Inflorescence spicate. Tribe III. ZOYSIEAE.
Inflorescence paniculate. Tribe IV. TRISTEGINEAE.
Flowering scale and palet chartaceous, cartilaginous or coriaceous, very different in appearance from the remaining scales. Tribe V. PANICEAE.
Spikelets much compressed laterally: hilum linear. Tribe VI. ORYZEAE.
B. Spikelets with the empty scales persistent, the rachilla hence articulated above them, 1–many-flowered: internodes of the rachilla of spikelets of 2 or more flowers long and readily measurable.
Stems herbaceous (except in one species of *Panicum*): leaf-blade sessile, not articulated with the sheath.
Spikelets borne in open or spike-like panicles or racemes, usually upon distinct and often long pedicels.
Spikelets 1-flowered. Tribe VII. AGROSTIDEAE.
Spikelets 2–many-flowered. Tribe IX. FESTUCEAE.
Spikelets borne in two rows, on short equal pedicels or sessile. Tribe VIII. CHLORIDEAE.
Stems woody: leaf-blade with a petiole-like base which is articulated with the sheath. Tribe X. BAMBUSEAE.

Tribe I. MAYDEAE

A tall stout grass with the pistillate spikelets enclosed in a globose white bead-like organ. 1. *Coix.*

Tribe II. ANDROPOGONEAE

First scale of the spikelet globose, rugose: racemes not hairy. 2. *Hackelochloa.*
Scales of the spikelet long, flat or convex: racemes hairy.
Racemes singly disposed.
Second scale of the sessile spikelet awnless: pedicellate spikelet smaller than the sessile one. 3. *Schizachyrium.*
Second scale of the sessile spikelet awned: pedicellate spikelet larger than the sessile one. 4. *Diectomis.*
Racemes in pairs, or sometimes 3's–5's. 5. *Andropogon.*

Tribe III. ZOYSIEAE

A low grass with a narrow spike-like inflorescence. 6. *Anthephora.*

Tribe IV. TRISTEGINEAE

A tall grass with a large panicle of awned spikelets. 7. *Arundinella.*

Tribe V. PANICEAE

1. Spikelets all perfect: leaf-blades sessile.
a. Spikelets not sunken in the rachis.
* Spikelets naked, not involucrate.
Scales 3.
Lowest scale with a thickened ring-like callus. 8. *Monachne.*
Lowest scale unappendaged.
Flowering scale with its opening turned from the rachis. 9. *Paspalum.*

Flowering scale with its opening turned toward the rachis. 10. *Anastrophus.*

Scales 4.

Perfect flowers 2. 11. *Isachne.*

Perfect flower 1.

Second empty scale not saccate at the base.

Empty scales not awned.

Spikelets in very slender 1-sided racemes which are usually whorled or approximate. 12. *Syntherisma.*

Spikelets in panicles or panicled racemes, the latter never whorled, commonly distant.

Spikelets long-hairy, acuminate. 13. *Trichachne.*

Spikelets glabrous or with only short hairs, usually orbicular to ovate, if lanceolate glabrous.

Spikelets hemispheric, orbicular or nearly so in outline, the rachis of the 1-sided racemes winged. 14. *Dimorphostachys.*

Spikelets not hemispheric, varying in outline, usually in panicles, rarely in racemes and then the rachis not winged.

Flowering scale without lateral pits or appendages at the base. 15. *Panicum.*

Flowering scale with pits or membranous appendages at the base. 16. *Ichnanthus.*

Empty scales awned or awn-pointed.

Stems creeping : leaf-blades short and broad. 17. *Oplismenus.*

Stems erect : leaf-blades long and narrow. 18. *Echinochloa.*

Second empty scale saccate at the base. 19. *Sacciolepis.*

** Spikelets involucrate.

Involucre of bristles. 20. *Chaetochloa.*

Involucre of 2 spine-bearing valves. 21. *Cenchrus.*

b. Spikelets sunken in one side of the broad flattened rachis. 22. *Stenotaphrum.*

2. Spikelets monoecious : leaf-blades with a petiole-like base. 23. *Olyra.*

Tribe VI. ORYZEAE

Grasses with broad flat leaf-blades and long narrow spikelets. 24. *Pharus.*

Tribe VII. AGROSTIDEAE

Flowering scale with three long awns. 25. *Aristida.*

Flowering scale awnless. 26. *Sporobolus.*

Tribe VIII. CHLORIDEAE

1. Spikelets with 1 perfect flower.

Spikes digitate or in whorls.

Second empty scale acute: awn of the flowering scales usually long. 27. *Chloris.*

Second empty scale truncate or 2-toothed: flowering scales awnless or awn-pointed. 28. *Eustachys.*

Spikes scattered, single. 29. *Heterosteca.*

2. Spikelets with 2–3 perfect flowers.

Spikes usually digitate: spikelets crowded.

Spikes with terminal spikelets. 30. *Eleusine.*

Spikes with the rachis extending beyond the spikelets in a manifest point. 31. *Dactyloctenium.*

Spikes distant: spikelets alternate. 32. *Leptochloa.*

Tribe IX. FESTUCEAE

Tall grasses with large dense hairy panicles and broad flat leaf-blades.

Dioecious: staminate spikelets glabrous. 33. *Gynerium.*

Hermaphrodite: spikelets hairy. 34. *Phragmites.*

Low grasses with open glabrous panicles.

Empty scales 2: flowering scales 3-nerved. 35. *Eragrostis.*

Empty scales 3–6: flowering scales many-nerved. 36. *Uniola.*

Tribe X. BAMBUSEAE

Grasses with woody stems and the leaves often fasciculately arranged. 37. *Arthrostylidium.*

1. COIX L. Sp. Pl. 972. 1753

1. COIX LACHRYMA-JOBI L. Sp. Pl. 972. 1753.

In wet places, frequent. Between Aibonito and Cayey, Heller 528; Rio Piedras, Goll 316; Adjuntas road, near Ponce, Heller 6075.

2. HACKELOCHLOA Kuntze, Rev. Gen. **2**: 776. 1891

Manisuris Sw. Prod. 25. 1788.

1. HACKELOCHLOA GRANULARIS (L.) Kuntze, Rev. Gen. Pl. **2**: 776. 1891.

Cenchrus granularis L. Mant. 575. 1771.

Manisuris granularis Sw. Prod. 25. 1788.

Near Mayaguez, Heller 4401.

3. SCHIZACHYRIUM Nees, Agrost. Bras. 331. 1829

1. SCHIZACHYRIUM brevifolium (Sw.) Nees; Kunth, Enum. **1**: 488. 1833.

Andropogon brevifolius Sw. Prod. 26. 1788.

Adjuntas road, near Ponce, Heller 6230.

4. DIECTOMIS H.B.K. Nov. Gen. & Sp. **1**: 193. 1815

1. DIECTOMIS FASTIGIATA (Sw.) H.B.K. Nov. Gen. & Sp. **1**: 193, *pl. 64.* 1815.

Andropogon fastigiatus Sw. Prod. 26. 1788.

Meadows on Mt. Santano, Coamo, Sintenis 3247.

5. ANDROPOGON L. Sp. Pl. 1043. 1753

Racemes not surrounded by bracts: spikelets awnless: foliage not lemon-scented.
  Stems tall and stout, the inflorescence large and much-branched. 1. *A. bicornis.*
  Stems low, tufted, slender, the inflorescence slender and consisting of but few branches. 2. *A. leucostachys.*
Racemes surrounded by sheathing bracts: spikelets awned: foliage lemon-scented. 3. *A. Nardus.*

1. ANDROPOGON BICORNIS L. Sp. Pl. 1043. 1753.

In dry soil, frequent. Luquillo Mts., Wilson 226; Santurce, Heller 597.

2. ANDROPOGON LEUCOSTACHYS H.B.K. Nov. Gen. & Sp. **1**: 187. 1815.

Sandy soil, frequent. Heller 933, 984 and 4396; Goll 326.

3. ANDROPOGON NARDUS L. Sp. Pl. 1046. 1753.

Santurce, Heller 229 (leaves only). The immature character of the only specimen of this grass we have seen from Porto Rico makes its definite determination impossible. In leaf character it strongly resembles this species.

6. ANTHEPHORA Schreb. Beschr. Graes. **3**: 105. 1810

1. ANTHEPHORA HERMAPHRODITA (L.) Kuntze, Rev. Gen. 759. 1891.

Tripsacum hermaphroditum L. Syst. Ed. 10, 1261. 1759.

Anthephora elegans Schreb. Beschr. Graes. **3**: 105. 1810.

In waste places, frequent. Santurce, Heller 165 and 1348.

7. ARUNDINELLA Raddi, Agrost. Bras. 37, *pl. 1.* 1823

1. ARUNDINELLA MARTINICENSIS Trin. Gram. Pan. 62. 1826.

Caguas, Heller, 934; Mayaguez, Heller, 4355; Adjuntas road, near Ponce, Heller 6256.

8. MONACHNE Beauv. Agrost. 49, *pl. 10.* 1812

Eriochloa H.B.K. Nov. Gen. & Sp. **1**: 94, *pl. 30, 31.* 1815.

Rachis of the inflorescence softly pubescent with short spreading hairs: outer scales of the spikelet pubescent with many long stiff hairs. 1. *M. punctata.*

Rachis merely scabrous on the angles: outer scales less pubescent and with shorter finer hairs. 2. *M. subglabra.*

1. MONACHNE PUNCTATA (L.).

Milium punctatum L. Syst. Ed. 10, 872. 1759.

Eriochloa punctata Hamilt. Prod. 5. 1825.

Humacao, Blauner; Adjuntas road, near Ponce, Heller 6298.

2. **Monachne subglabra** sp. nov.

A tall somewhat branching grass with rather broad, flat leaf-blades. Stems 8–12 dm. long, glabrous, the nodes densely pubescent with short, spreading hairs: leaves numerous; sheaths usually shorter than the internodes and much shorter than the blades, ciliate on the margins, the lower ones papillose-hirsute between the nerves; ligule a ring of short hairs; blades linear to lanceolate, flat, ascending, or the longer ones drooping, glabrous, very rough on the margins, long-acuminate at the apex, generally narrowed toward the base, 1–3 dm. long and 7–17 mm. wide: inflorescence finally somewhat exserted, the rachis hispidulous on the ridges: racemes ascending, commonly 6–10, the larger 4–6 cm. long, the rachis hispidulous on the margins and more or less setiferous: spikelets on shorter pedicels which usually bear a few long hairs, 3.5 mm. long and about 1.3 mm. wide, elliptic to ovate-lanceolate, acute, a short semicircular first scale usually present, the second and third scales about equal in length, acute, rather sparingly pubescent with appressed hairs, 5-nerved, the third scale bearing in its axil a palet of equal length and a staminate flower, the fourth scale about three fourths as long as the spikelet, elliptic, mucronate, finely transverse-rugose.

Collected at Martin Peña January 31, 1899, by Heller, no. 380.

9. PASPALUM L. Syst. Ed. 10, 855. 1759

1. Racemes scattered along the axis of the inflorescence.
   - *a.* Spikelets broadly elliptic to orbicular, one half as wide as long; rachis of racemes manifestly wing-margined.
     - * Spikelets not margined.
       - Stems erect or nearly so, stout: leaf-blades long: outer scales of the spikelet with a midnerve.
         - Spikelets glabrous.
           - Third scale of the spikelet white or yellowish at maturity: basal

leaf-sheaths very broad and reticulated, at least when dry.
Spikelets about 1.5 mm. long: racemes numerous.
1. *P. densum.*
Spikelets about 2.5 mm. long: racemes 12–18.
2. *P. Underwoodii.*
Third scale dark brown at maturity: basal sheaths not broad nor reticulated. 3. *P. Boscianum.*
Spikelets pubescent.
Spikelets elliptic, about one half as wide as long, the pubescence appressed. 4. *P. Helleri.*
Spikelets broadly oval or obovate, the pubescence spreading.
Spikelets less than 1.5 mm. long. 5. *P. hemisphaericum.*
Spikelets 2.5–3 mm. long. 6. *P. virgatum.*
Stems slender, creeping at the base: leaf-blades short, rarely more than 5 cm. long: outer scales of the spikelet without a midnerve.
7. *P. orbiculatum.*
** Spikelets surrounded by a broad toothed margin. 8. *P. fimbriatum.*
b. Spikelets narrowly elliptic, less than one half as broad as long: rachis of racemes barely, if at all, margined. 9. *P. Portoricense.*
2. Racemes long and slender, arising in pairs at the apex of the stem, rarely with another one a short distance below. 10. *P. conjugatum.*

1. PASPALUM DENSUM Poir. in Lam. Encycl. **5**: 32. 1804.

A single specimen of this species from Porto Rico has been seen by the writer, and is the type in the herbarium of Lamarck at Paris; it was collected by Ledru.

2. **Paspalum Underwoodii** sp. nov.

A tall perennial with reticulated basal leaf-sheaths, elongated leaf-blades and rather dense inflorescence. Stems 8–12 dm. tall, erect, rather stout at the base: leaves numerous at the base; sheaths glabrous, the basal ones strongly reticulated, at least when dry, rather abruptly narrowed into the blade at or below the middle, equitant; ligule a scarious ring; blades 4–7 dm. long, about 1 cm. wide, long-acuminate at the summit, exceedingly rough on the lower surface, densely hirsute on the upper surface, serrulate on the margins: inflorescence 1.5–2.5 dm. long: racemes 12–18, sessile or nearly so, ascending or nearly erect, the lower ones 7–10 cm. long, the rachis including its serrulate wings about 1 mm. wide and more or less setiferous, usually purplish: spikelets in pairs in two rows, on short hispid pedicels, yellowish green, usually more or less purplish tinged, glabrous, broadly obovate, 2.5 mm. long, 2 mm. broad, and about 0.8 mm. thick, apiculate, the 2 outer scales 3-nerved, apiculate, the third scale yellowish-white, oval, 2.2 mm. long and about 1.7 mm. wide, minutely striate.

Type collected by Underwood and Griggs along roadsides, Mayaguez to Joyua, June 14 to July 22, 1901, no. 149. The following specimens also belong here: Plaza de Humacao, Eggers 676, 1881; between Mayaguez and Añasco, Sintenis 1223, 1885, and near Guanica, 3412*b*, 1885, of the same collector; Santurce, Heller 594; near Mayaguez, Heller 4368.

Related to *P. densum* Poir., but that has more numerous racemes and much smaller spikelets.

3. PASPALUM BOSCIANUM Fluegge, Gram. Mon. 171. 1810.

Paspalum purpurascens Ell. Bot. S. C. & Ga. **1**: 108. 1817.

El Yunque, Luquillo Mts., Wilson 43.

4. **Paspalum Helleri** sp. nov.

A tufted nearly glabrous perennial. Stems 4–8 dm. tall, finally branching above, rather slender, smooth and glabrous, the nodes glabrous: leaves usually 3; sheaths smooth and glabrous, shorter than the internodes; ligule a scarious ring about 1 mm. long; blades erect, or drooping at the end, smooth and glabrous on the surfaces with the exception of some long hairs on the upper surface just back of the ligule, the margins rough, linear, acuminate at the apex, the larger ones 1.5–2.5 dm. long and 5–7 mm. wide: racemes 2–4, sometimes single on the branches, slender, 6–9 cm. long, the rachis more or less flexuous, winged and about 1 mm. wide: spikelets in pairs, 2 mm. long and about 1 mm. wide, elliptic, obtuse, the two outer scales 3-nerved, the first scale pubescent with long weak hairs, the second one glabrous, the third scale and palet greenish.

In fields and waste places. Type collected at Santurce, Jan. 9, 1899, by Heller, no. 10. No. 164, secured by this collector at the same place, also belongs here.

5. PASPALUM HEMISPHAERICUM Poir. in Lam. Encycl. **5**: 31. 1804.

Paspalum paniculatum Gaertn. Fruct. Sem. **2**: 2, *pl. 80.* 1791. In part. Not Linnaeus.

Near Mayaguez, Heller 4399; Adjuntas road, near Ponce, Heller 6227.

6. PASPALUM VIRGATUM L. Syst. Ed. 10, 855. 1759.

In sandy soil, common. Luquillo Mts., Wilson 227; Rio Piedras, Heller 130 and 625; Cataño, Heller 1373; Underwood and Griggs 794.

7. PASPALUM ORBICULATUM Poir. in Lam. Encycl. **5**: 32. 1804.

Paspalum pusillum Vent.; Fluegge, Gram. Mon. 100. 1810.

Wet banks, south of San Juan, Heller 664.

8. PASPALUM FIMBRIATUM H.B.K. Nov. Gen. & Sp. **1**: 93, *pl. 28.* 1815.

In ditch, Coamo to Ponce, Underwood and Griggs 576; Ponce, Heller 6219.

9. **Paspalum Portoricense** sp. nov.

A low tufted nearly glabrous slender perennial. Stems about 1 dm. tall, glabrous, with the exception of a few hairs at the nodes, simple: leaves 2 or 3; sheaths glabrous, usually shorter than the internodes and shorter than the blades; ligule scarious, acute, 1–2 mm. long; blades ascending, flat, rather thin, the upper surface with some long hairs at the very base and a few scattered ones elsewhere, sparingly ciliate on the margins, the lower surface glabrous, linear, acuminate at the apex, usually more or less narrowed toward the base: inflorescence very slender, about 2 cm. long, of 1 or 2 erect branches: spikelets in pairs, one on a long and the other on a short pedicel, elliptic, 1.8 mm. long and 0.7 mm. wide, usually purplish tinged, glabrous, the first and second scales 3-nerved, the third scale greenish-white, a little shorter than the outer scales, obtuse.

Type collected between Aibonito and Cayey, February 8, 1899, by Heller, no. 524.

10. PASPALUM CONJUGATUM Berg. Act. Helv. **7**: 129, *pl. 8.* 1772.

Near Mayaguez, Heller 4397; Mayaguez to Joyua, Underwood and Griggs 175; Luquillo Mts., Wilson 159.

10. ANASTROPHUS Schlecht. Bot. Zeit. 8: 681. 1850.

1. ANASTROPHUS COMPRESSUS (Sw.) Schlecht.; Doell. in Mart. Fl. Bras. **2**^{2}: 102. 1877.

Milium compressum Sw. Prod. 24. 1788.

Rio Blanco, Blauner.

11. ISACHNE R. Br. Prod. 196. 1810

1. **Isachne angustifolium** sp. nov.

A prostrate leafy branching perennial, forming large mats, with narrow leaf-blades and rather small panicles. Stems 1 m. long or less, glabrous or very sparingly pubescent below, the uppermost internode minutely appressed-pubescent: leaves numerous; sheaths glabrous or sparingly hispid, papillose-ciliate on the margins, those on the main stem shorter than the internodes, those on the branches overlapping; ligule a ring of short hairs; blades erect or ascending, linear to linear-lanceolate, acuminate, rough and green on the upper surface, smooth and glaucous on the lower surface, the lower the shorter, only 2–3 cm. long, increasing in length toward the summit where they are 5–10 cm. long and 4–6 mm. wide: panicles long-exserted, 5–8 cm. long, their main axis and widely spreading primary branches minutely pubescent, the secondary branches similarly pubescent and at an angle of about 45° with the primary branches: spikelets about 1.5 mm. long, on shorter pedicels, the two outer scales about equal in length, equalling or a little shorter than the spikelet and sparingly pubescent at the apex, obtuse, the first broadly oval, the second almost orbicular, the two flowering scales glabrous, yellowish, about 1.3 mm. long.

On the summit of El Yunque, Luquillo Mountains, Porto Rico, Wilson, no. 160.

12. SYNTHERISMA Walt. Fl. Car. 76. 1788

Spikelets one quarter as wide as long or more, acute, the fourth scale yellowish when mature. 1. *S. fimbriatum.*

Spikelets one fifth as wide as long, acuminate, the fourth scale greenish when mature. 2. *S. setosum.*

1. SYNTHERISMA FIMBRIATUM (Link) Nash, Bull. Torrey Club, **25**: 302. 1898.

Digitaria fimbriata Link, Hort. Berol. **1**: 226. 1827.

Waste places, common. Cataño, Heller 107, and Bayamon, Heller 422.

2. SYNTHERISMA SETOSUM (Desv.) Nash, Bull. Torrey Club, **25**: 300. 1898.

Digitaria setosa Desv.; Hamilt. Prod. 6. 1825.

Near Mayaguez, Heller 4398.

13. TRICHACHNE Nees, Agrost. Bras. 85. 1829

1. TRICHACHNE INSULARE (L.) Nees, Agrost. Bras. 86. 1829.

Andropogon insularis L. Syst. Ed. 10, 1304. 1759.

Panicum leucophaeum H.B.K. Nov. Gen. & Sp. **1**: 97. 1815.

In fields and along streams, frequent. Heller 136 and 650; Underwood and Griggs 131 and 564; Goll 479; Adjuntas road, near Ponce, Heller 6158.

14. DIMORPHOSTACHYS Fourn. Comptes-Rendus Acad. Par. **80**: 441. 1875

1. DIMORPHOSTACHYS PEDUNCULATA (Poir.) Fourn. Mex. Pl. **2**: 15. 1886.

Paspalum pedunculatum Poir. in Lam. Encycl. Suppl. **4**: 315. 1816.

Adjuntas road, near Ponce, Heller 6354.

15. PANICUM L. Sp. Pl. 55. 1753

1. Apex of the panicle-branches not extending beyond the insertion of the spikelets.
  - *a*. Stems herbaceous.
    - Spikelets scattered, on long pedicels of varying length.
      - Fourth scale of the spikelet smooth: low grasses, less than 5 dm. tall.
        - Panicle large and effuse, over 1 dm. long: spikelets numerous, less than 1.5 mm. long.
          - Leaf-blades narrowly ovate, rarely exceeding 7 cm. long: spikelets 1 mm. long. 1. *P. brevifolium.*
          - Leaf-blades lanceolate, rarely less than 1 dm. long: spikelets 1.3 mm. long. 2. *P. trichanthum.*
        - Panicle small, less than 1 dm. long: spikelets few, 1.5 mm. long or more.
          - Stems erect, if prostrate in age never rooting at the lower nodes.
            - Spikelets less than 2 mm. long.
              - Leaf-blades with the upper surface hirsute, the larger over 1 cm. wide. 3. *P. comophyllum.*
              - Leaf-blades with the upper surface glabrous or merely puberulent, less than 5 mm. wide. 4. *P. Nashianum.*
            - Spikelets more than 2 mm. long. 5. *P. consanguineum.*
          - Stems erect only toward the end, the base prostrate and rooting at the lower nodes.
            - Leaf-blades lanceolate, pubescent, less than 5 mm. wide. 6. *P. parvifolium.*
            - Leaf-blades ovate-lanceolate, more than 5 mm. wide. 7. *P. oplismenoides.*
      - Fourth scale of the spikelet transversely rugose: tall stout grasses. 8. *P. maximum.*
    - Spikelets crowded on short nearly equal pedicels, in short clusters on one side of the panicle-branches.
      - Outer scales of the spikelet with cross-veinlets connecting the longitudinal nerves. 9. *P. paniculatum.*
      - Outer scales without cross-veinlets.
        - Fourth scale of the spikelet transversely rugose.
          - Spikelets about 2 mm. long: stems slender: leaf-blades ovate-lanceolate, usually less than 5 cm. long. 10. *P. prostratum.*

Spikelets about 3 mm. long : stems stout : leaf-blades long and linear. 11. *P. molle.*

Fourth scale of the spikelet smooth. 12. *P. laxum.*

b. Stems woody, bamboo-like. 13. *P. latifolium.*

2. Apex of the panicle-branches extending beyond the insertion of the spikelets in an awn-like appendage.

Second scale of the spikelet 3-nerved, the fourth scale smooth. 14. *P. Sintenisii.*

Second scale of the spikelet 5–7-nerved, the fourth scale transversely rugose. 15. *P. flavescens.*

1. PANICUM BREVIFOLIUM L. Sp. Pl. 59. 1753.

In fields and waste places, frequent. Santurce, Heller 157; Martin Peña, Heller 387; Luquillo Mts., Wilson 283; Adjuntas road, near Ponce, Heller 6094.

2. PANICUM TRICHANTHUM Nees, Agrost. Bras. 210. 1829.

In moist ground, between Aibonito and Cayey, Heller 531.

3. **Panicum comophyllum** sp. nov.

A tufted densely pubescent perennial, finally much-branched, with broad flat leaf-blades and rather large panicles. Stems 3–4 dm. tall, hirsute with long ascending hairs : leaves 5–7; sheaths densely hirsute with spreading hairs, the primary ones shorter than the internodes and the blades; ligule a ring of stiff hairs about 2 mm. long; blades spreading or ascending, flat, softly hirsute on both surfaces with spreading hairs, those on the upper surface the longer, ciliate on the margin with stiffer hairs; those on the main stem oblong-linear to ovate-lanceolate, acute, barely cordate at the somewhat clasping base, 5–7 cm. long, 10–13 mm. wide : panicle somewhat exserted, 5–7 cm. long and about as broad, broadly ovate, the main axis pubescent with short spreading hairs, its branches somewhat ascending : spikelets broadly obovate, 1.5 mm. long and about 1 mm. wide, pubescent with spreading hairs.

Type collected in rich soil at Santurce, January 9, 1899, by Heller, no. 12.

Related to *P. ciliosum* Nash, of the southern United States, but readily distinguished by its softly pubescent leaf-blades.

4. PANICUM NASHIANUM Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 7: 79. 1897.

In sand, quite common. Vega Baja, Heller, 639; Manati to

Vega Baja, Underwood and Griggs 955; Santurce, Heller 982*b* and 6442.

5. PANICUM CONSANGUINEUM Kunth, Rev. Gram. **1**: 36. 1829.
Sandy soil, Santurce, Heller 982.

6. PANICUM PARVIFOLIUM Lam. Ill. **1**: 173. 1791.
Bayamon, Sintenis 1216.

7. **Panicum oplismenoides** sp. nov.

A smooth and glabrous prostrate leafy perennial with much of the habit of *Oplismenus setarius*, with short broadly lanceolate leaf-blades and spreading panicles. Stems slender, rooting at the lower nodes, branching: leaves numerous; sheaths much shorter than the internodes and about one half as long as their blades; ligule a very narrow scarious ring; blades spreading, shorter than the internodes, broadly lanceolate to ovate-lanceolate, often somewhat undulate on the margins, 2–3 cm. long, 6–10 mm. wide: panicles but little exserted, broadly ovate, 3–4 cm. long, the branches spreading: spikelets elliptic, 1.8–2 mm. long and a little less than 1 mm. broad, the first scale a little more than one half as long as the spikelet, 5-nerved, broadly ovate, obtuse, the second and third about equal in length, 5-nerved, a little exceeding the white flowering scale, the third scale with a manifest palet nearly as long as itself.

Collected on the edge of a ditch at Vega Baja, May 9, 1899, by Heller, no. 1316.

Related in habit and general appearance to *P. polygonoides* Lam., but in that the leaf-blades are smaller and with hispid sheaths and the spikelets globular.

8. PANICUM MAXIMUM Jacq. Ic. Pl. Rar. **1**: 13. 1781–6.
Martin Peña, Heller 377; Martin Peña and Lecheria, Goll 31.

9. **Panicum paniculatum** (L.).

Paspalum paniculatum L. Syst. Ed. 10, 855. 1759.

Panicum fasciculatum Sw. Prod. 22. 1788.

In sandy and rocky soil, frequent. Rio Piedras, Heller 135; Aguadilla, Heller 4528; Sprengel; H. Wydler 311; Adjuntas road, near Ponce, Heller 6226 and 6302.

It may be of interest to note here that the specimen from which Sloane's figure (Hist. Jam. *pl. 72, f. 2*) was drawn, and on which Linnaeus based his *Paspalum paniculatum*, has been examined by the writer, and that it is what is commonly known as *Panicum fasciculatum* Sw.

10. PANICUM PROSTRATUM Lam. Ill. **1**: 171. 1791.

Cane field between Ponce and Coamo, Heller 497.

11. PANICUM MOLLE Sw. Prod. 22. 1788.

Along railroad, Bayamon, Heller 100; Yauco, Heller 6293.

12. PANICUM LAXUM Sw. Prod. 23. 1788.

In fields, common. Between Aibonito and Cayey, Heller 522; Santurce, Heller 983; Cataño, Heller 1378.

13. PANICUM LATIFOLIUM L. Sp. Pl. 58. 1753.

In woods and thickets, common. Maricao, Sintenis 215; Mayaguez, Heller 4375; Arecibo, Heller 343; Luquillo Mts., Wilson 350; Coamo, Goll 699; Bayamon, Goll 227.

14. **Panicum Sintenisii** sp. nov.

A tufted glabrous perennial with long narrow flat leaf-blades and a slender panicle. Stem 4–6 dm. tall, slender, producing panicle-bearing branches from the upper sheaths: leaves about 4; sheaths several times shorter than the internodes and the blades; ligule a ring of short hairs; blades narrow and elongated, flat toward the apex, but folded below for a considerable distance, at least when dry, giving the blade a long-stalked appearance, 1–2 dm. long and about 2 mm. wide at the flat portion, the lower folded portion about one quarter this width, long-acuminate: panicle very slender, 4–7 cm. long, its branches appressed, 1–2 cm. long, each running out into a bristle-like termination as do its divisions: spikelets about 2 mm. long, acute, as are also all the scales, the first scale 1-nerved, about one half as long as the spikelet, the second one 3-nerved, about two thirds as long as the spikelet, the third scale 5-nerved and equalling the fourth scale or a little shorter than it, the fourth scale very acute.

In woods, Guanica, Sintenis 3463.

Related to *P. Chapmani* Vasey, but that has stouter spikelets and all the scales with more nerves.

15. PANICUM FLAVESCENS Sw. Prod. 23. 1788.

Near Mayaguez, Heller 4373 and 4488.

16. ICHNANTHUS Beauv. Agrost. 56, *pl. 12, f. 1.* 1812

1. ICHNANTHUS PALLENS (Sw.) Munro; Benth. Fl. Hongk. 414. 1861.

Panicum pallens Sw. Prod. 23. 1788.

In wet shaded places, common. Bayamon, Heller 92; Santurce, Heller 826; Mayaguez, Heller 4374 and 4479; Puente Fluco, Goll 884; Adjuntas road, near Ponce, Heller 6093.

17. OPLISMENUS Beauv. Fl. Owar. **2**: 14, *pl. 68.* 1807

1. OPLISMENUS SETARIUS (Lam.) R. & S. Syst. **2**: 481. 1817.

Panicum setarium Lam. Ill. **1**: 170. 1791.

In moist soil, frequent. Piñon, Goll 623; Adjuntas road, near Ponce, Heller 6303.

18. ECHINOCHLOA Beauv. Agrost. 53, *pl. 11, f. 11.* 1812.

1. ECHINOCHLOA COLONA (L.) Link, Hort. Berol. **2**: 209. 1833.

Panicum colonum L. Syst. Ed. 10, 870. 1759.

In fields and waste places, common. Cataño, Heller 108; Mayaguez, Heller 4409; Coamo Springs, Goll 660.

19. SACCIOLEPIS Nash, in Britt. Man. 89. 1901.

1. **Sacciolepis striata** (L.).

Holcus striatus L. Sp. Pl. 1048. 1753.
Panicum striatum Lam. Ill. **1**: 172. 1791.
Panicum gibbum Ell. Bot. S. C. & Ga. **1**: 116. 1817.
Sacciolepis gibba (Ell.) Nash, in Britt. Man. 89. 1901.

Wet ground, near Santurce, Heller 1363.

20. CHAETOCHLOA Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 4: 38. 1897

Setae at the base of the spikelet 5 or more, involucrate, antrorsely scabrous.
  Setae short, not more than twice as long as the spikelet: inflorescence usually slender. 1. *C. purpurascens.*
  Setae longer; inflorescence stout. 2. *C. imberbis.*
Setae 1–3 at the base of each spikelet, not involucrate, retrorsely scabrous above, antrorsely below. 3. *C. scandens.*

1. CHAETOCHLOA PURPURASCENS (H.B.K.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 13. 1900.

Setaria purpurascens H.B.K. Nov. Gen. & Sp. **1**: 110. 1815.

In fields and waste places, frequent. Santurce, Heller 14 and 329.

2. CHAETOCHLOA IMBERBIS (Poir.) Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 4: 39. 1897.

Panicum imberbe Poir. in Lam. Encycl. Suppl. **4**: 272. 1816.

Sintenis 208 (*fide* Scribn. & Merr. l. c.); Adjuntas road, near Ponce, Heller 6240.

CHAETOCHLOA IMBERBIS GENICULATA (Lam.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 12. 1900.

Panicum geniculatum Lam. Encycl. **4**: 727. 1797.

Differs from the species in having stouter geniculate stems, broader leaf-blades, and a longer inflorescence.

Humacao, Blauner 233.

3. CHAETOCHLOA SCANDENS (Schrad.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 17. 1900.

Setaria scandens Schrad., Schult. Mant. **2**: 279. 1824.

Sintenis 6498 (*fide* Scribn. & Merr. l. c.).

21. CENCHRUS L. Sp. Pl. 1049. 1753

Involucres 4-6-flowered, armed at the base with erect barbed bristles. 1. *C. echinatus.*

Involucres 2–flowered, armed at the base with generally shorter reflexed spines. 2. *C. tribuloides.*

1. CENCHRUS ECHINATUS L. Sp. Pl. 1050. 1753.

In sandy waste places, common. Santurce, Heller 3 and 1346; Cayey, Underwood and Griggs 406.

2. CENCHRUS TRIBULOIDES L. Sp. Pl. 1050. 1753.

Fajardo, Blauner 242.

22. STENOTAPHRUM Trin. Fund. Agrost. 175. 1820

1. STENOTAPHRUM SECUNDATUM (Walt.) Kuntze, Rev. Gen. 794. 1891.

Ischaemum secundatum Walt. Fl. Car. 249. 1788.

Roadside near Bayamon, Heller 1241; in sand, Manati to Vega Baja, Underwood and Griggs 959.

23. OLYRA L. Syst. Ed. 10, 1261. 1759

1. Olyra latifolia L. Syst. Ed. 10, 1261. 1759.

Near Mayaguez, Heller 4443 and 4583.

24. PHARUS P. Br. Hist. Jam. 344. 1756

1. Pharus Brasiliensis Raddi, Agrost. Bras. 21. 1823.

Rio Blanco, Blauner; ravine, Coamo Springs, Underwood and Griggs 505 and 845.

25. ARISTIDA L. Sp. Pl. 82. 1753

1. Aristida dispersa Trin. & Rupr. Mem. Acad. Sci. St. Petersb. VI. **7**: 129. 1829.

Guanica, Sintenis 3766.

26. SPOROBOLUS R. Br. Prod. 169. 1810

Stems tufted, not arising from rootstocks.
  Spikelets about 2 mm. long, the second scale half as long or less. 1. *S. Indicus.*
  Spikelets about 3 mm. long, the second scale fully as long. 2. *S. purpurascens.*
Stems arising from long branching rootstocks. 3. *S. Virginicus.*

1. Sporobolus Indicus (L.) R. Br. Prod. 170. 1810.

Agrostis Indica L. Sp. Pl. 63. 1753.

In sandy soil, common. Santurce, Heller 985 and 1275; Lecheria, Goll 22.

2. Sporobolus purpurascens (Sw.) Hamilt. Prod. 5. 1825.

Agrostis purpurascens Sw. Prod. 25. 1788.

Near Mayaguez, Heller 4590.

3. Sporobolus Virginicus (L.) Kunth, Rev. Gram. **1**: 67. 1829.

Agrostis Virginica L. Sp. Pl. 63. 1753.

On sand dunes and in sandy soil, frequent. Santurce, Heller 1412; Maunabo, Sintenis 5084.

27. CHLORIS Sw. Prod. 25. 1788.

Spikes slender: flowering scale lanceolate, not long-ciliate. 1. *C. radiata.*
Spikes stout: flowering scale oval, long-ciliate on the margins above. 2. *C. Paraguiensis.*

1. Chloris radiata Sw. Prod. 26. 1788.

In moist soil and waste places, common. Cataño, Heller 109;

Rio Piedras, Heller 195 and 196; Bayamon, Underwood and Griggs 883; Santurce, Heller 6380.

2. CHLORIS PARAGUIENSIS Steud. Syn. Pl. Gram. 204. 1855.

Chloris barbatum Sw. Fl. Ind. Occ. **1**: 200. 1797. Not *Andropogon barbatum* L. Amoen. Acad. **5**: 412. 1759.

Near Mayaguez, Heller 4417.

28. EUSTACHYS Desv. Nouv. Bull. Soc. Philom. 2: 188. 1810

1. EUSTACHYS PETRAEA (Sw.) Desv. Nouv. Bull. Soc. Philom. **2**: 189. 1810.

In sand, Vega Baja, Heller 131; Santurce, Heller 6422.

29. HETEROSTECA Desv. Nouv. Bull. Soc. Philom. 2: 188. 1810

1. **Heterosteca rhadina** sp. nov.

Stems tufted, 2.5–4 dm. long, slender, finally prostrate at the base and branching above: leaves several; sheaths strongly nerved, glabrous, or the lower ones sometimes more or less pubescent; ligule a narrow scarious ring; blades flat, narrowly linear, acuminate, more or less hirsute on both surfaces, especially on the upper, less than 1 dm. long, 1–2 mm. wide: spikes 3–7, short, spreading or reflexed, of 1–3 spikelets, the 3-angled rachis hispidulous on the angles, its internodes long, usually exceeding one half the length of the empty scales: spikelets distant, appressed to the rachis, the purple empty scales very acute, 1-nerved, hispidulous on the stout midrib, the first shorter than the second which is 5–6 mm. long, the first flowering scale 3-nerved, the nerves extending into short awns, the lateral ones barely reaching the apex of the body of the scale, the central one extending about 1 mm. beyond it, enclosing a perfect flower and a palet longer than its body, the second flowering scale likewise 3-nerved, the nerves extending into hispidulous awns longer than the body, enclosing a staminate flower and a longer palet.

Collected on the Adjuntas road, near Ponce, by Heller, no. 6057, and distributed as *Bouteloua Americana* (Sw.) Scribn. The *Aristida Americana* cited in the synonymy of *Bouteloua litigiosa* Lag. by Grisebach (Fl. Brit. W. I. 537) is accredited to Swartz (Obs. Bot. *t. 2, f. 2*). Swartz, however, distinctly indicates there the real authorship of the species by quoting the original Linnaean description in the Systema Naturae. Both authors refer the plant to Jamaica, so that the plate and description of Swartz may in all probability be safely taken as characterizing the Linnaean plant also. The genus *Heterosteca* was founded by Desvaux on one species, *H. juncifolia.* At a later date he probably became acquainted with the *Aristida Americana* Sw., for in a subsequent publication (Jour. de Bot. **3**: 68. 1813) he changes the name to *Heterosteca Americana,* citing *H. juncifolia* as a synonym.

The plant of Swartz is quite different from the one we have under consideration, differing in the more numerous spikes with more spikelets, and in the second flowering scale being reduced to a 3-awned empty rudiment.

30. ELEUSINE Gaertn. Fruct. **1**: 7. 1788

1. ELEUSINE INDICA (L.) Gaertn. Fruct. **1**: 8. 1788.

Cynosurus Indicus L. Sp. Pl. 72. 1753.

In cultivated and waste ground, common. Cataño, Heller 110; between Ponce and Coamo, Heller 499; Mayaguez, Heller 4410; Lecheria, Goll 20.

31. DACTYLOCTENIUM Willd. Enum. 1029. 1809

1. DACTYLOCTENIUM AEGYPTIUM (L.) Willd. Enum. 1029. 1809.

Cynosurus Aegyptius L. Sp. Pl. 72. 1753.

In cultivated and waste grounds, common. Santurce, Heller 155; Mayaguez, Heller 4411; Guanica, Sintenis 3469; Guayama, Goll, 513; Coamo Springs, Goll 661; Bayamon, Underwood and Griggs 900.

32. LEPTOCHLOA Beauv. Agrost. 71, *pl. 15, f. 1.* 1812

1. LEPTOCHLOA VIRGATA Beauv. Agrost. 166. 1812.

Moist ground near Añasco, Heller 4535.

33. GYNERIUM H. & B. Pl. Aequin. **2**: 112, *pl. 115.* 1809

1. GYNERIUM SACCHAROIDES H. & B. Pl. Aequin. **2**: 112, *pl. 115.* 1809.

Along streams, Yauco, Underwood and Griggs 718.

34. PHRAGMITES Trin. Fund. Agrost. 134. 1820

1. Phragmites occidentalis (Sieb.) Trin.; Steud. Nomen. Ed. **2**, **2** : 324. 1841.

Arundo occidentalis Sieb.; Schult. Mant. **2** : 289. 1824.

Near Guanica, Heller 6289. This specimen is doubtfully referred here, its immaturity preventing a more definite determination. It was distributed as *Arundo Donax ;* it hardly appears to be that plant, however. It may only be a form of the world-wide *P. Phragmites.* Mature flowering specimens of this are greatly desired.

35. ERAGROSTIS Beauv. Agrost. 70, *pl. 14*, *f. 11*. 1812

Flowers perfect : stems not rooting at the lower nodes.
  Palet long-ciliate on the margins : panicle narrow and spike-like. 1. *E. ciliaris.*
  Palet not long-ciliate : panicle loose and open.
    Annual : leaf-blades less than 1 dm. long. 2. *E. Purshii.*
    Perennial : leaf-blades more than 1 dm. long. 3. *E. Elliottii.*
Flowers dioecious : stems creeping. 4. *E. hypnoides.*

1. Eragrostis ciliaris (L.) Link, Hort. Berol. **1** : 192. 1827.
Poa ciliaris L. Syst. Ed. 10, 875. 1759.

In waste and cultivated soil, common. Bayamon, Heller 101 ; Santurce, Heller 156 and 6404 ; Cabo Rojo, Sintenis 838 ; Bayamon, Underwood and Griggs 895 ; Ponce, Heller 6218.

2. Eragrostis Purshii Schrad ; Shlecht. Linnaea, **12** : 451. 1838.

Rio Piedras, Heller 197 ; between Aibonito and Cayey, Heller 551 ; Montellano, Goll 473 ; Adjuntas road, near Ponce, Heller 6198. These specimens are doubtfully referred here.

3. Eragrostis Elliottii S. Wats. Proc. Am. Acad. **25** : 140. 1890.

Poa nitida Ell. Bot. S. C. & Ga. **1** : 162. 1817. Not Lam. 1791.

Eragrostis nitida Chapm. Fl. S. U. S. 564. 1860.
Moist sandy soil, Santurce, Heller 584.

4. Eragrostis hypnoides (Lam.) B.S.P. Prel. Cat. N. Y. 69. 1888.

Poa hypnoides Lam. Ill. 185. 1791.
Roadsides, Rio Piedras, Heller, 649 ; Bayamon, Sintenis 1225.

36. UNIOLA L. Sp. Pl. 71. 1753

1. UNIOLA RACEMIFLORA Trin. Bull. Sc. Acad. St. Petersb. **1**: 68. 1836.

Near Salinas de Cabo Rojo, Sintenis 839.

37. ARTHROSTYLIDIUM Rupr. Mem. Acad. St. Petersb. VI. **5**: 117. 1839

Leaf-blades very narrowly linear or hair-like.	1. *A. capillifolium.*
Leaf-blades lanceolate.	2. *A. multispicatum.*

1. ARTHROSTYLIDIUM CAPILLIFOLIUM Griseb. Mem. Am. Acad. II. **8**: 531. 1863.

Near Sabanagrande, climbing on tall trees, Sintenis 3891.

2. ARTHROSTYLIDIUM MULTISPICATUM Pilger in Urban, Symb. Ant. **2**: 341. 1901.

In woods near Maricao and Adjuntas, Sintenis 209 and 4016 (according to Pilger).

A number of other specimens of the Bambuseae are in collections, but they are without inflorescence and so undeterminable.

NEW YORK BOTANICAL GARDEN.

On the Physiological Action of some of the Heavy Metals in Mixed Solutions *

BY

Rodney H. True — *U. S. Department of Agriculture*

AND

William J. Gies — *New York Botanical Garden*

It has been shown by several investigators that, in mixed solutions containing the lighter metals, the physiological action of the electro-positive elements may in a degree antagonize each other, and a mixture of several toxic solutions of these compounds may be much less harmful than any one of the constituents taken singly. Researches concerning the physiology of sea-water have shown this to be conspicuously the case. Work on soil-solutions by Kearney and Cameron † has developed a similar situation.

The neutralizing action of the various ions on those of the heavy metals has been less studied and the present paper presents, in a preliminary way, results gained from a series of experiments performed during the summer of 1902 in the Plant Physiological Laboratory at Wood's Hole, Massachusetts.

As a test object, the primary radicle of seedlings of *Lupinus albus* was used. The method of procedure consisted essentially in suspending the seedlings on glass rods for at least 24 hours in each experiment, in such a manner as to immerse the radicles in the solution under study. In most cases the seedlings were under observation for 48 hours. At least four seedlings were used in each experiment of a series, and our deductions were drawn from the figures for average growth. With only a very few exceptions each member of the quartette manifested the same tendency. The solutions were carefully prepared from pure chemicals and were believed to be very accurate. The experiments were made in beakers.

In order to get a basis for comparison, we made a number of solutions of different compounds of each of the heavy metals used, and determined the strongest concentration in which the plants were able to make appreciable growth. This point of undoubted growth furnished a point of departure in making comparisons. The accompanying tables give the average growth-rates at the end of twenty-four hours.

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* Read by title at the meeting of the Botanical Society of America, held at Washington, D. C., December, 1902.

† Kearney, T. H., and Cameron, F. K. Some Mutual Relations between Alkali Soils and Vegetation. U. S. Dep. Agric. Rep. No. 71. 1902.

TABLE I

SIMPLE SOLUTIONS.* HEAVY METALS. AVERAGE GROWTH-RATES IN MILLIMETERS †

Conc. Gm. Mol.	$CuSO_4$	$CuCl_2$	$Cu(CH_3CO_2)_2$	$AgNO_3$	$HgCl_2$	$ZnSO_4$
m/8192					2.0	6.0
m/16384	0.5	1.0	1.0		9.0	9.0
m/32768	1.0	1.0	2.0		13.0	18.0
m/65536	3.5	3.0	3.0	2.0	16.0	18.0
m/131072	11.0	10.5	11.0	6.0		16.0
m/262144		16.0	15.0	13.5		
m/524288				22.0		
Check.	14.0	14.0	12.0	12.5	15.0	15.5

Table I summarizes the growth-rates obtained in a series of solutions of salts of copper, silver, mercury and zinc. In order to test the possible antagonizing influence of compounds with other bases, a number of salts of sodium, potassium, calcium and magnesium were used.

TABLE II

SIMPLE SOLUTIONS. LIGHT METALS AND UREA. AVERAGE GROWTH-RATES IN MILLIMETERS

Conc. Gm. Mol.	NaCl	Na_2SO_4	KCl	KNO_3	$Ca(NO_3)_2$	$CaCl_2$	$CaSO_4$	$MgCl_2$	Urea
m/8						1.5			0.5
m/16	2.5					9.6			1.0
m/32	3.5	1.3	0.7	3.4	20.0	16.0			3.5
m/64	7.5	1.0	2.0	4.0	20.5		35.0		8.0
m/128	13.5	2.8	6.6	8.0	21.0				
m/256		5.8	7.0	9.0	21.0				
m/512								5.5	
m/1024								6.2	
m/2048								9.4	
m/4096								12.5	
Check.	15.5	10.0	10.0	14.0	10.0	12.5	13.0	10.0	15.2

A similar point indicating the maximum concentration permitting growth was obtained for each of the salts of the lighter metals taken. This was necessary in order to get some idea of the permissible concentrations in which the latter might be used. Table II presents in brief the growth-rates made by the lupine roots in solutions of the salts of the second group of metals (and of urea).

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* All control experiments in this and subsequent series were made in water which had been very carefully distilled several times. All of the solutions were prepared from distilled water obtained under constant conditions.

† The growth-rates recorded in these tables are those for the first 24 hours.

SIMPLE MIXTURES

Knowing now the effect, on the growth-rate, of the heavy metals under study, also that of the salts of the lighter metals which were made use of, we have a basis for ascertaining the action of these compounds when their solutions are mixed. The method of procedure in this connection consisted briefly in mixing, with a series of graded solutions of the heavy metals, a definite quantity of the salts of the lighter metals. Two general classes of salts could be chosen for this purpose; first, those in which a common anion occurs in combination with the different cations made use of; second, salts in which also the anions differed. By making up solutions molecularly, as was done in every case, a comparison of results obtained from the same cations, combined in the two ways indicated, would enable us to judge of the action of the anions.

Table III summarizes growth-results obtained by growing lupine radicles in a series of solutions of copper salts mixed with salts of one lighter base in varying degrees of concentration. The growth-rates obtained are directly comparable to those resulting from the action of the simple solutions of the heavy metals. It will be noted that when copper sulphate is mixed with calcium sulphate, the latter containing $m/144$ grams per liter, a corresponding growth-rate is found in the case of the simple solution (Table II) at a concentration of copper sulphate indicated by $m/65536$, and in the case of the mixed solution (Table III) at a concentration of $m/16384$. These facts indicate that the presence of the given amount of calcium sulphate enables the plant to withstand four times as much copper as it was able to withstand when the latter occurred in simple solution. A further inspection of the tables shows that when calcium sulphate is present in weaker solutions, the antagonizing action is still strong, even when calcium sulphate is present in a concentration of $m/512$.

When to copper chloride, magnesium chloride is added in a series of graded concentrations, an inspection of the tables shows that in general little, if any, diminution in the toxic action of the copper follows. This seems to indicate that magnesium is not able to diminish the poisonous action of the copper under the conditions present.

When to copper chloride, calcium chloride is added in the proportion of *m*/128, a decided decrease in the killing power of the copper is seen. When to copper chloride, sodium chloride, *m*/16, is added, a strikingly reversed situation appears. Not only is the harmful action of the copper not diminished, but the mixture seems to be slightly more poisonous than the simple copper solution or the simple sodium solution. This would seem to indicate that to the poisonous action of the copper that of the sodium chloride itself is added.

TABLE III

MIXED SOLUTIONS. HEAVY METAL AND LIGHT METAL. COMMON ANIONS. AVERAGE GROWTH-RATES IN MILLIMETERS

Concent. of Solution of Heavy Metal	$CuSO_4 + CaSO_4$			$CuCl_2 + MgCl_2$			$CuCl_2$ +	$CuCl_2$ +	$AgNO_3$ +	$HgCl_2$ +	$ZnSO_4$ +
	$CaSO_4$ *m*/144	$CaSO_4$ *m*/256	$CaSO_4$ *m*/512	$MgCl_2$ *m*/128	$MgCl_2$ *m*/256	$MgCl_2$ *m*/512	$CaCl_2$ *m*/128	NaCl *m*/16	KNO_3 *m*/256	$CaCl_2$	$CaSO_4$ *m*/256
m/2048		0.0	0.0								33.5
m/4096	0.0	0.0	0.0							0.0	39.0
m/8192	0.0	0.0	1.0					0.0		0.0	37.5
m/16384	3.0	3.0	1.5	1.0	2.0	2.0	2.0	0.0		1.0	37.0
m/32768	8.5	7.0	3.5	1.0	3.0	1.0	6.0	0.0	1.0	2.0	
m/65536	14.0	17.0	14.0	4.0	4.0	3.0	10.5	0.5	3.0	8.0	
m/131072		19.5				5.0	15.0	1.0	5.0		
Check in water	12.0	11.0	11.0	10.0	14.0	12.0	14.5	12.0	11.5	12.0	13.0
Check in Solution of Light Metal	29.0	26.5	26.0	4.0	9.0	4.5	20.0	1.0		24.5	35.0

When to a solution of silver nitrate a solution of potassium nitrate, *m*/256, is added, no very marked change in the action of the heavy metal is noticeable, the growth-rate coinciding approximately with that seen in the solution of the pure silver salt. What difference there is seems to be in the direction of greater toxicity.

When to mercuric chloride, calcium chloride, *m*/256, is added no diminution in the poisonous action of the corrosive sublimate is seen. Indeed, the mixture is markedly more poisonous than the solution of the simple salt. Zinc sulphate gives a very different result when calcium sulphate, *m*/256, is added. Whereas growth is much retarded in a *m*/8192 solution of zinc sulphate, in the mixture at *m*/2048 growth is more than twice as rapid as in the control grown in water. We have here a very marked stimulation in the growth-rate, resulting from the addition of the lighter metal to the zinc.

When to salts of the heavy metals compounds of the lighter metals are added, in the form of salts in which the anion differs from that in the copper compound, a condition of things is found which is not essentially different from that just cited. In Table IV results bearing on this point are presented.

TABLE IV

MIXED SOLUTIONS. HEAVY METAL AND LIGHT METAL. DIFFERENT ANIONS. AVERAGE GROWTH-RATES IN MILLIMETERS

Concent. of Solution of Heavy Metal	$CuSO_4$. + $CaCl_2$ *m*/128	$CuSO_4$ + $CaCl_2$ *m*/128(dup.)	$Cu(CH_3CO_2)_2$ + $Ca(NO_3)_2$ *m*/32	$HgCl_2$ + $Ca(NO_3)_2$ *m*/32	$CuSO_4$ + Urea *m*/64
m/4096				0.0	
m/8192			2.0	1.0	
m/16384	1.5	3.0	5.0	6.0	
m/32768	3.0	4.0	9.5	16.0	0.0
m/65536	7.0	10.0			0.5
m/131072		16.5			4.5
Check	12.0	15.5	13.0	14.0	11.5

It will be noted that when calcium chloride, *m*/128, is added to copper sulphate, a marked diminution in the poisonous action of the copper compound takes place to a degree equal to that seen when the anions are similar. When to copper acetate cal-

TABLE V

MIXED SOLUTION. COPPER SULPHATE WITH CANE SUGAR. AVERAGE GROWTH-RATES IN MILLIMETERS

Concent. of Copper Solution	Cane Sugar 2*m*	Cane Sugar *m*	Cane Sugar *m*/2	Cane Sugar *m*/4	Cane Sugar *m*/8	Cane Sugar *m*/16	Check in Water
m/65536	0.0	2.7	4.0	7.5	5.5	6.5	15.5

cium nitrate, m 164, is added, a similar situation results. In the case of solutions of mercuric chloride to which calcium nitrate has been added, we find no amelioration of the poisonous action of the corrosive sublimate, the growth being, if anything, less in the mixed solution than in that of the mercuric chloride alone.

In view of what has been said, the question naturally arises as to the effect of non-electrolytes in solution with the heavy metals. In this connection but two compounds were studied : cane sugar and urea. Tables IV and V present the results obtained. It will be seen that in a solution of copper sulphate, $m/65536$, to which cane sugar in concentrations varying from m to $m/16$ has been added, the growth-rate in general increases as the concentration of cane sugar diminishes. The growth-rate is markedly greater in the solution of copper sulphate containing cane sugar varying in concentration from $m/4$ to $m/16$ than in the copper solution alone. This growth-rate was not a persistent feature, however, since in all the mixtures except that containing cane sugar at the least concentration, $m/16$, no growth took place in the second twenty-four hours. It appears, therefore, that when cane sugar is added in proper proportions, as in these experiments, the poisonous action of copper is somewhat diminished. This is probably due to the formation of copper saccharate and a consequent lessening of the number of Cu ions.*

As regards the effect of the addition of urea, $m/64$, it appears that the inhibiting action of the mixed solution is greater than that of the simple copper salt, the addition of the urea seeming to increase the total poisonous action.

COMPLEX MIXTURES

In order further to test the effect of additions of lighter metals to salts of the more poisonous elements, more complicated syntheses were made. These were of two classes : one mixed solution in which all of the salts present had a common anion ; a second mixed solution in which the anion of the salt of the heavy metal did not appear in any of the compounds of the lighter metals. Mixtures were made in which, in addition to a copper salt, salts of sodium, magnesium, calcium and potassium, successively, were added. In every case, Ca excepted, the concentration in which each compound was present was that which, while distinctly retarding growth, still permitted it. We have, therefore, in every case, a salt entering into the combination in a concentration sufficiently great to be a distinctly toxic agent. The concentrations and other data in this connection appear in Table VI.

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* See Loeb, J., and Gies, W. J. Weitere Untersuchungen über die entgiftenden Ionenwirkungen und die Rolle der Werthigkeit der Kationen bei diesen Vorgängen. Archiv für die ges. Physiologie, 93 : 261. 1902.

It will be noted in each case that the copper salt permits a slight growth. When the sodium salt is added, the mixture becomes somewhat more harmful than the copper salt alone. The addition of magnesium to the mixture raises the growth-rate to a point beyond that reached in the copper solution, indicating a slightly beneficial antagonistic effect. When to these the calcium salt is added, the growth-rate immediately assumes practically normal proportions. This neutralizing or antitoxic effect of the calcium is very marked. When to the combination just referred

TABLE VI

COMPLEX MIXTURES OF ONE HEAVY METAL AND AN INCREASING NUMBER OF LIGHTER METALS. AVERAGE GROWTH-RATES IN MILLIMETERS

With common anions									With different anions		
(*a*) Contents of Solutions		Av. Growth 24 hrs.	(*b*) Contents of Solutions		Av. Growth 24 hrs	(*c*) Contents of Solutions		Av. Growth 24 hrs.	Contents of Solutions		Av. Growth 24 hrs.
	mol			mol			mol			mol	
$CuCl_2$	65536	5.5	$CuCl_2$	32768	1.0	$CuCl_2$	65536	2.5	$Cu(CII_3.CO_2)_2$	65536	8.0
$CuCl_2$ $NaCl$	65536 64	2.5	$CuCl_2$ $NaCl$	32768 64	1.5	$CuCl_2$ $NaCl$	65536 128	1.0	$Cu(CH_3.CO_2)_2$ Na_2SO_4	65536 128	3.0
$CuCl_2$ $NaCl$ $MgCl_2$	65536 64 512	7.0	$CuCl_2$ $NaCl$ $MgCl_2$	32768 64 512	2.5	$CuCl_2$ $NaCl$ $MgCl_2$	65536 128 1024	6.0	$Cu(CH_3.CO_2)_2$ Na_2SO_4 $MgCl_2$	65536 128 512	8.0
$CuCl_2$ $NaCl$ $MgCl_2$ $CaCl_2$	65536 64 512 32	14.5	$CuCl_2$ $NaCl$ $MgCl_3$ $CaCl_2$	32768 64 512 32	7.0	$CuCl_2$ $NaCl$ $MgCl_2$ $CaCl_2$	65536 128 1024 64	9.0	$Cu(CH_3.CO_2)_2$ Na_2SO_4 $MgCl_2$ $CaCl_2$	65536 128 512 32	17.0
$CuCl_2$ $NaCl$ $MgCl_2$ $CaCl_2$ KCl	65536 64 512 32 128	19.0	$CuCl_2$ $NaCl$ $MgCl_2$ $CaCl_2$ KCl	32768 64 512 32 128	5.5	$CuCl_2$ $NaCl$ $MgCl_2$ $CaCl_2$ KCl	65536 128 1024 64 256	10.0	$Cu(CH_3.CO_2)_2$ Na_2SO_4 $MgCl_2$ $CaCl_2$ KNO_3	65536 128 512 32 128	22.0
Check		13.5			10.5			10.5			13.0

to the potassium salt is added, the growth-rate is still further increased. In the last mixture we have five salts, each, with the exception of the calcium compound, in a concentration strong enough to interfere distinctly with growth. As a result of their presence together, not only is there no addition of poisonous effects, but a neutralization of toxicity to such degree as to permit in the mixed solution a growth-rate equal to or greater than that seen in the check culture.

When the concentration of copper solution was doubled and the concentration of the other salts left as before, we found that the action of the copper was more slowly overcome, and even in the most complex mixtures studied, the growth-rate was still below that of the check. Apparently, the poisonous activity of the copper in these cases was greater than such as could be neutralized by the quantities of other salts added to it. When, on the other hand, the concentration of the copper solution was kept as in the first instance and the concentration of the lighter salts added was diminished by half, the neutralizing action of the latter was markedly less. In the most complex mixtures under these latter conditions the observed growth-rate only equaled that of the control. Apparently this fact was due to the unneutralized copper action, since each of the other salts present were below a harmful concentration.

Returning, now, to mixtures in which the anion of the copper salt is not duplicated in any of the other salts present, we see a result essentially like that just noted. When to copper acetate, for example, salts of the metals used before are added in quantities equal to those indicated in Table VI, a similar result is seen. The growth-rate in the pure copper salt in this case is somewhat greater, since the $CH_3.CO_2$ anion is slightly less poisonous than the Cl or the SO_4 anion. The addition of the sodium salt again increases the toxicity of the mixture. The further addition of the magnesium salt diminishes the harmful action somewhat, the activity of the mixture being, roughly, the same as that of copper acetate alone. The entrance of the calcium salt, as before, produces a marked acceleration of growth, the rate jumping to a point considerably above the control. The final addition of the potassium salt still further increases this stimulation. As a result of this experiment it appears that it is immaterial here, as before, whether the lighter metals enter the solution in compounds containing an anion common to that of the heavy metal, or whether the anions be different.

DISCUSSION OF RESULTS

From the evidence at hand in these experiments it appears that, in solutions of salts, the conspicuously effective component of the molecule is the cation or the metal. This presumption, raised by the similar physiological effects produced by the cation of various salts of the heavy metals in equimolecular quantities, is strengthened by the action of mixtures containing a salt of the heavy metal with salts of lighter metals.

In case several salts having the same cation are mixed in solution the same lack of conspicuous influence on growth on the part of the anion is to be seen.* It is clear that the effect exerted upon the lupine roots by the salts of the heavy metals tested, differed according to the concentration of the salts. When sufficiently diluted, solutions containing copper, silver, mercury or zinc ions exerted a more or less clearly marked *stimulating* effect on growth. At a greater concentration, perhaps double that causing stimulation, a retarding influence was usually seen, and in a concentration approximately doubling this, growth was much interfered with ; and on again doubling the concentration, little or no growth took place.

The effect of adding solutions containing Ca, Mg or Na ions was seen to vary with the character of the cation introduced. In mixtures containing but two salts (Tables III and VI) sodium seemed to show an increased poisonous action as though that of the sodium were added to that of the cation of the heavy metal. When to a solution of copper, a salt of magnesium was added, the mixture seemed to act with nearly the same intensity as the simple solution containing the copper in like quantity, exerting, therefore, little influence on the poisonous activity of the copper. When calcium was added, a marked reduction of the poisonous activity of copper ions was observed, a result seen even more strikingly in the case of zinc. Investigations by Swingle,* Clark,† Rumm and others on the action of Bordeaux mixture, although concerning very different proportions from those here involved, all testify to this power of calcium to neutralize the poisonous action of copper. Whereas the presence of calcium reduced the harmful effects of the copper to about one fourth of that seen in the simple copper solution, the antagonizing action of the calcium reduced the toxic action of the zinc to, at most, one sixteenth of that of the simple zinc solution. In the case of silver, the addition of calcium seemed to exert no ameliorating action. As far as the evidence at hand goes, it appears that such ameliorating action as was observed and would be expected stands in an inverse relation to the poisonous activity of the heavy metal.

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* The physiological action of every dissociated salt in solution is doubtless an expression of the resultant biological effect of its component cations and anions. In these experiments the influence of the cations was predominant.

From the above, as well as from the work of others, it appears conclusive that certain cations in mixed solutions exert a physiological action antagonistic to that exerted by other cations. The question next arises as to the nature of this modification and its seat. Does a mixed solution of calcium sulphate and copper sulphate or copper chloride, for example, produce the change (which brings about this physiological result) by affecting the condition of the copper in the solution outside of the cell, or does it bring about modifications within the cell itself? Is this antagonism an extracellular chemical change or an intracellular physiological change?

We have two sorts of cases to deal with. In the one case the salts have a common anion and in the other case the anions differ. We may set aside any such changes as the formation of double salts or the setting back of molecular ionization in the former case, since it has been shown that like results are seen when the mixed salts have common anions. This would seem to be a probable situation from *a priori* reasoning also, since in most cases the solutions of the salts of the heavy metals were so dilute that practically complete ionization took place. In that event, no matter what its associated anion was, the metal acted as free ions.

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* Swingle, W. T. Bordeaux Mixture. U. S. Dep. Agric. Div. Veg. Path. and Physiol. Bull No. 9. 1896.

† Clark, J. F. The Toxic Properties of some Copper Compounds with special reference to Bordeaux Mixture. Bot. Gaz. **33** : 26. 1902.

In the cases of our mixtures of salts having different anions, chemical reactions might be regarded as possible, with a consequent change in the forms of molecules. Here again, however, the great dilution of the salt of the heavy metal in our most important mixtures produced complete or nearly complete ionization, the heavy metal acting practically as free ions. We can then hardly regard changes of an ordinary chemical nature as being responsible for the differences in the physiological results. We think that interior physiological modifications are responsible for the observed differences in growth rate. This belief implies that the simple salt of the heavy metal and the mixture of this salt with that of a lighter metal, after penetration into the cell, affect the processes there being carried on in such a way as to bring about different results on cellular growth. In studying the effect on growth of simple solutions of copper and calcium salts, for example, we see that at the concentrations employed copper retards growth whereas the calcium salts greatly stimulate it. With each we have, in all probability, to do with antagonistic phases of physiological action. When we examine the results in cases like the above, it seems highly probable that the so-called antitoxic action of ions is due to different interior physiological modifications, and that the growth-rate observed in such experiments as these represents the physiological sum of oppositely acting stimuli, or of antagonistic protoplasmic changes.*

It has been shown that when salts of heavy metals are sufficiently dilute they exert a *stimulating* effect on growth, and when solutions of calcium and similar salts are concentrated enough, they hinder or entirely prevent growth, and may, in the case of the more soluble chloride and nitrate, prove fatal. Coupin † has shown that at different dilutions compounds exhibit *three distinct phases of physiological action.* When the solution is sufficiently dilute it seems too attenuated to produce any effect on growth. As the concentration increases, a *stimulating* phase is seen, which, on further concentration, passes over into the *retardation* phase—pronounced in proportion to the concentration.

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* Loeb and Gies, *l. c.*, 267.

† Coupin, H. Sur la toxicité du chlorure de sodium et de l'eau de mer e l'égard des végétaux. Rev. Gén. Bot. **10**: 177. 1898.

In the mixtures of copper and calcium employed in our experiments, we may have had concentrations of each salt in different phases of action due to the degree of concentration. In $CuCl_2$, *m*/65536, we see that the Cu concentration is in the phase hindering growth, the resulting elongation of the root being about 3 mm. When $CaCl_2$, *m*/128, was tested, it was found to be in a concentration markedly stimulating when referred to the control in water, growing 20 mm. in the former case, against 14.5 mm. in the check. These opposite tendencies were brought together in the mixed solution with the result that the concentration (in terms of the copper salt permitting the growth-rate seen in the simple copper solution) moved up to approximately four times that observed in the simple copper solution. The stimulating action of the calcium seems to have operated against the retarding action of the copper, and the result is a marked diminution in the poisonous action of the copper.

The opposite result is seen in the mixture containing $CuCl_2$ and NaCl. The latter is in its growth-retarding phase until more dilute than *m*/128. Hence at *m*/16 it is in its growth-retarding phase, and when added to $CuCl_2$ at *m*/65536, likewise in this phase, the result is a sum of toxicity and an increased depression of growth-rate follows the combined action of the two. This also applies to the mixtures containing magnesium.

In considering the more complex mixtures of salts, indicated in Table VI, the chemical nature and influences of the resulting solutions are not readily determined. Much more concentrated solutions result in such mixtures with consequent decrease in dissociation. The probability that we are dealing with various kinds of non-ionized molecules, as well as with an indefinite number of ions, makes it impossible to speak definitely with confidence of the significance of our results in this connection. In general one may say that here, as in sea water, another complicated mixture of molecules and ions, the entrance of the calcium salt into the mixture is the stage in the synthesis at which the growth-rate approaches that seen in the check, and the final addition of the potassium salt seems further to increase the growth-rate. Or, in other words, all the salt solutions except the calcium entered the mixture in a concentration at which singly they would cause a retardation of the growth-rate without bringing it to a standstill. Of the compounds present, therefore, the calcium salt only entered in a concentration representing the stimulus phase. The marked effect following the entrance of the calcium and the potassium may, in part, be due in these experiments to the cumulative increase of concentration of the solution, with the corresponding decrease in the rate of ionization and the diminished number of active ions. The fact that the potassium salt, although added in a concentration hindering growth when taken singly, increased the growth-rate when added to the mixture as its last member, seems to strengthen this supposition. Of course, changes of this nature represent changes in the solution itself and lie outside of the cell, and should not be confused with the mutually antagonistic intracellular action of ions in the case of very dilute solutions.

The Phyllodes of Oxypolis filiformis, a Swamp Xerophyte*

BY ROSINA J. RENNERT

A large number of species of higher plants which live in ponds, marshes and other extremely moist habitats present structural characters of a xerophytic nature which have been most difficult of interpretation. A special study of the phyllodes of *Oxypolis filiformis* † was undertaken by the author in the hope that some additional light might be thrown on the subject. This work was carried on in the New York Botanical Garden under the direction of Dr. D. T. MacDougal, to whom I am indebted for valuable advice and fruitful suggestions.

Oxypolis filiformis is an umbellifer which grows in swamps and along the borders of ponds in the southeastern United States, as far north as Delaware. The leaves exhibit curious modifications by which they depart widely from the uniformly broad or widely dissected umbelliferous type, being reduced to stiff grayish-green awl-shaped phyllodes, which have a structure as if made up of a number of sections of varying lengths, the joints being distinctly noticeable and marking the position of peculiar septa in the interior tissues. This habit of the leaves gives the plant a rush-like appearance, an effect which is heightened by the small size of the cauline, and the strong development of the basal phyllodes. The entire phyllode is flattened along one side. A minute pit is to be observed externally to every septum, occurring in the middle of the slightly flattened surface.

Briquet ‡ has given a detailed account of the results of his examination of this plant with respect to the anatomy of the phyllodes. He describes the epidermis as a single layer of cells with curved outer walls protected by a thickened outer membrane and a folded cuticle. The stomata were noted as either flush with the surface, or sunken slightly below, being about 48 to 54 μ in length. Directly underneath the epidermis is a hypoderm composed of small sclerotic cells with a small lumen. The hypoderm is one to three layers in thickness, and is interrupted only underneath the stomata. The chlorophyl-bearing tissue consists of three to six layers of cells, the outer ones of which are palisaded. The innermost layers are more loosely arranged. Internal to the chlorophyl-bearing cells is a cylinder of four or five layers of large thin-walled cells, designated as endoderm by Briquet. The fibro-vascular bundles are situated in this tissue. The pericycle comes into contact with the chlorophyl-bearing tissue in places, however. The axial portions of the phyllodes were found to consist of thin-walled stellate elements which are in contact at the tips of the rays. The septa were found to be composed of sclerotic cells with numerous branching canals extending radially through the walls. The fibro-vascular bundles are unbranched in the intervals but break up at the septa and form a mesh of anastomosing branches, which however do not traverse the septa radially to any great distance.

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* Read before the Botanical Society of America, by invitation, at Pittsburg, Pa., July 1, 1902.

† OXYPOLIS FILIFORMIS (Walt.) Britton. *Tiedemannia teretifolia* (Muhl.) DC.

‡ Briquet, J. Etude de la feuille du *Tiedmannia teretifolia* DC. Bull. Herb Boiss. 5: 461–465. 1897.

Briquet explains the seemingly anomalous possession of transpiration-hindering hypoderm by this marsh plant by the fact that it is subject to two extremes of conditions. The mechanical advantages from the cylindrical form of the phyllodes, and the aërating capacity of the stellate tissue would be of advantage during the early spring season, when the plant is more or less submerged. The shape of the leaf would present a reduced surface and the hypoderm would check transpiration during the mid-summer season after the waters have subsided.

My own examination of this plant and the results of the experimental tests made with it have revealed some structural features not mentioned by Briquet, and lead to a somewhat different interpretation of its adaptative features.

Some plants brought from Georgia and Florida in 1901 and 1902 were grown in the greenhouse under various conditions as described below. The septa in the phyllodes of these specimens were found to consist chiefly of small thin-walled cells containing chlorophyl, and resembling the elements of the other chlorophyl-bearing tissue, with only an occasional thick-walled sclerotic cell. The endoderm was found to be continued on the surfaces of the septa. I am not able to account for the difference in these septa as observed by Briquet and myself, except to suggest that his plants were grown under conditions which induced the sclerosis of the elements of the septa and which he has not described.

The most important additional fact concerning the structure of these organs, however, is that all of the specimens in the herbarium of the New York Botanical Garden, and of those cultivated by myself in the open, exhibit the pits or depressions mentioned above, and this feature is to be seen even in the first leaf of the seedlings. These pits seem to be the external openings of oil or resin glands which are situated immediately below each septum. The pit is partly closed by a chlorophylless outgrowth of the lower margin, which can be distinguished by the unaided eye as a minute scale. Goebel * describes similar outgrowths on the phyllodes of *Crantzia linearis*, an umbellifer of the same habit as *Oxypolis*, and despite the fact that they occur along one side of the leaf only, he holds the opinion that they are vestigial leaf-divisions. This conclusion can hardly be valid with respect to the pits and scales of *Oxypolis*. These formations are absent from the basal septa as they would be if vestigial leaf-divisions, but as a matter of fact the scales and pits originate on a line ninety degrees from the plane of the stipules. Furthermore the specialized structute of the formations in question militates against their acceptance as vestiges.

It was found that the floor of the pit is on a level with the plane of the diaphragm. It is this floor and the flap which closes the orifice only, whose structure indicates a specialization of function. With these exceptions the invagination is lined by a continuation of the normal epidermal cells of the phyllode, covered by a cuticle continuous with that on the outside of the leaf. The floor and flap have an epidermis of smaller cells the outer walls of which are slightly convex, forming small papillae. No cuticle is present. The small openings which occur in this epidermis measure about 19 μ in diameter and are formed by two cells broadly elliptical in shape. Directly below these epidermal cells and making up the greater part of the flap is a mass of irregularly shaped cells dovetailed compactly into each other. The epidermal cells as well as the cells of this tissue contain a great amount of resin or oil. Enlarged tracheae are to be found in great numbers leading into this compact tissue and forming a solid mass below it. The anastomosing bundles of the septa end here. In the light of this peculiar structure, it seems reasonable to regard these pits as glands for the secretion of oil or resin.

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* Goebel, K. Organographie der Pflanzen, 494. 1901.

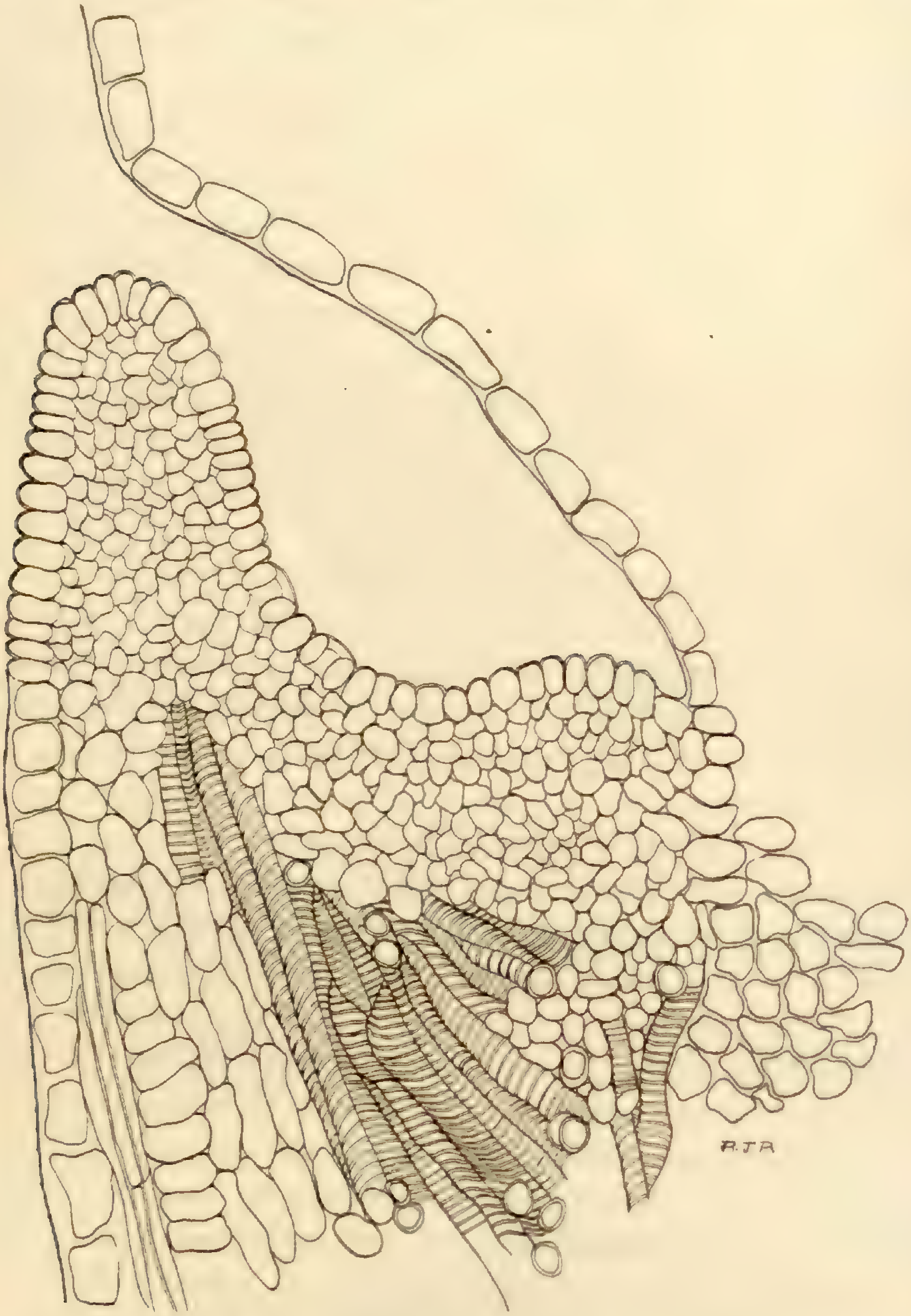

FIG. 1. Oil-gland of phyllode, × 140.

In opposition to Briquet, I am led to the conclusion that *Oxy-*

polis does not owe its peculiar structure to an adaptation to wet and dry periods, but that it is a true swamp or bog xerophyte in accordance with the generalization of Schimper, who supposes that the water of bogs and swamps contains such a large proportion of humic acid as to render absorption difficult. Plants growing in such places therefore have difficulty in securing a requisite supply, as if growing under arid conditions. Not all plants are capable of absorbing water from a mixture exhibiting a higher pressure than that of the cell-sap of the absorbing organs.

Dr. Shaw * has pointed out that the vegetation of a pond in its final stage is always xerophytic and has drawn attention to the fact that the continual deposit of organic material around the margin of a pond will produce a zone so much filled with humic acid as to be entirely devoid of vegetation. Dr. Cowles † has upheld this view of the xerophytic character of an undrained swamp and has frequently noted the remarkable assemblage of xerophytic adaptations such as leathery or hairy leaves and special structures for water absorption exhibited by the flora of peat bogs. In confirmation of this standpoint Dr. Cowles has pointed out that if plants growing in swamps of this type are xerophytic we ought to find them thrving in dry regions. And this he reports to be true; *Clethra alnifolia, Spiraea tomentosa* and *Myrica cerifera*, generally conceded swamp plants, have been found thriving and in all respects normal on dry hillsides.

As Briquet has indicated, the most superficial examination of the plant brings to light the unmistakably xerophytic character of the reduced leaf-surface and the strong development of hypoderm. On the other hand many of the characters which Briquet regards as demonstrating the hydrophytic nature of the plant, seem when viewed in the light of recent ecological work, to be adaptations either for water storage or the prevention of transpiration. The large thin-walled empty celled endoderm certainly exhibits capacity for water storage. The thick cuticle and the waxy incrustation of the epidermis, the accessory cells and the sunken position of the stomata, and the presence of resin glands all point to the conclusion that the conservation of water is the chief purpose met by the striking structural adaptations.

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*Shaw, C. H. The Development of Vegetation in the Morainal Depressions of the Vicinity of Wood's Hole. Bot. Gaz. 33: 437. 1902.

† Cowles, H. C. Bot. Gaz. 27: 293. 1899.

This view is strengthened by the experimental results. Two series of cultural tests were made. In one series a number of plants in pots of soil were enclosed in bell-jars and were thus grown in a saturated atmosphere. Others were entirely submerged in tanks of water. The phyllodes produced under these conditions were similar. In both cases these organs were delicate, hollow, terete, translucent, light green in color, and exhibited no trace of glands or pits. The stipules were membranous and reduced in width. The epidermal cells were without wax or cuticle and were greatly elongated longitudinally. The stomata were partly exserted and were of a reduced number, but retained their characteristic structure. In consequence of the regularity of the epidermal

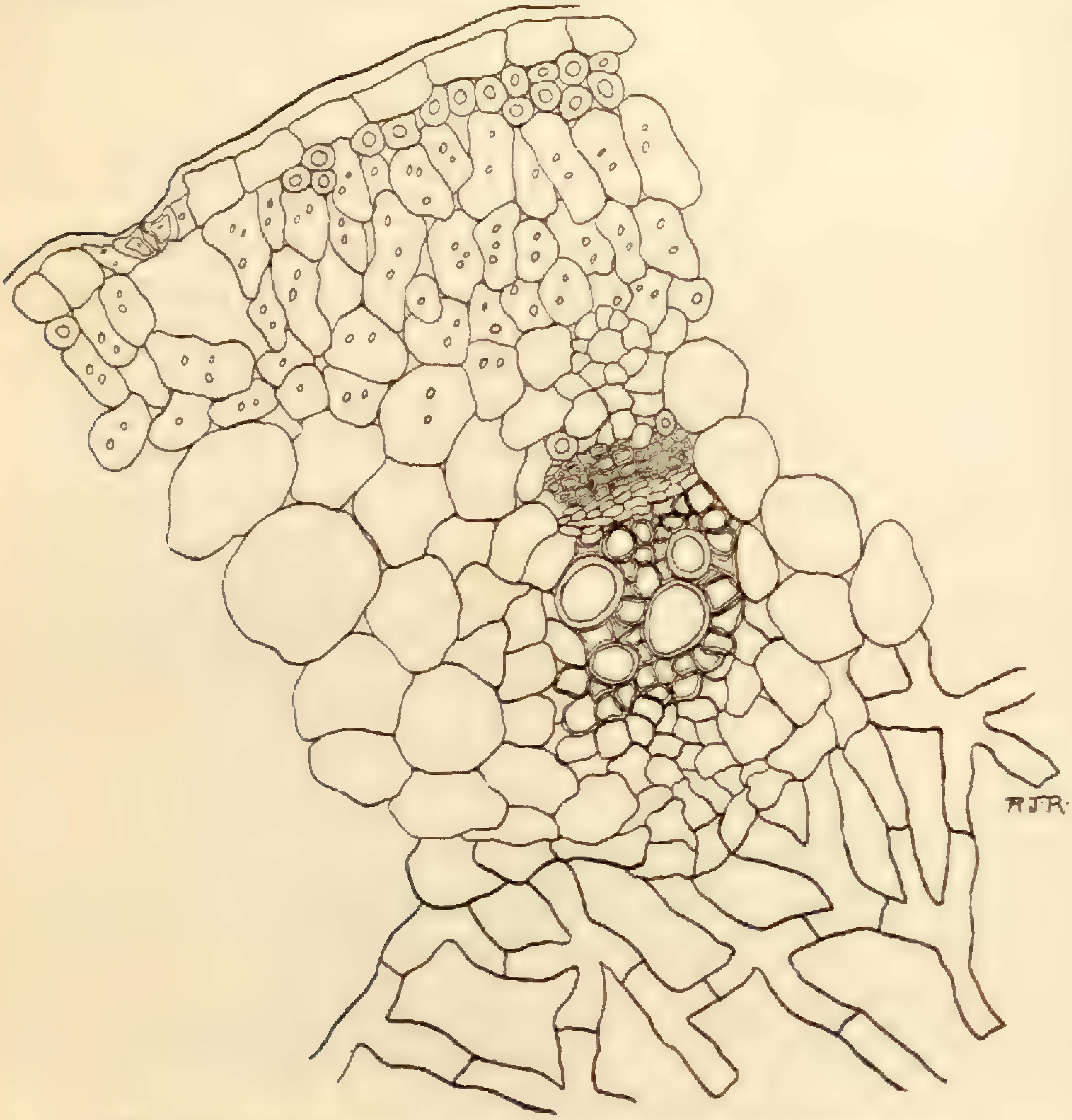

FIG. 2. Partial cross-section of phyllode, xerophytic form, × 140.

rows of cells, the stomata occurred in definite rows separated from each other by five sterile epidermal rows. Hypoderm was absent. The chlorophyl-cells followed directly upon the epidermis. This tissue was reduced to about three rows, and the palisade character of the first row of cells was not very marked. The endoderm was also less developed. It consisted of only one to three rows of cells. The stellate tissue of the other form was entirely absent here. As a consequence of the meager development of endoderm the fibro-vascular bundles jutted out into the central cavity. The xylem in the bundles was reduced and the position of the resin duct changed. In the normal type it was always to be found outside of the phloëm; in these phyllodes it was on the other side of the bundle near the xylem. This position of the duct has been pointed out by Van Tieghem as more primitive or juvenile. The diaphragms were composed entirely of thin-walled cells and the anastomosing bundles contained in them were much weaker and, contrary to the habit in the solid phyllode, anastomosed as freely at the center of the septum as about the edge. No trace of glands in the phyllode have been found and there is consequently no general convergence of bundles toward any single point in the margin.

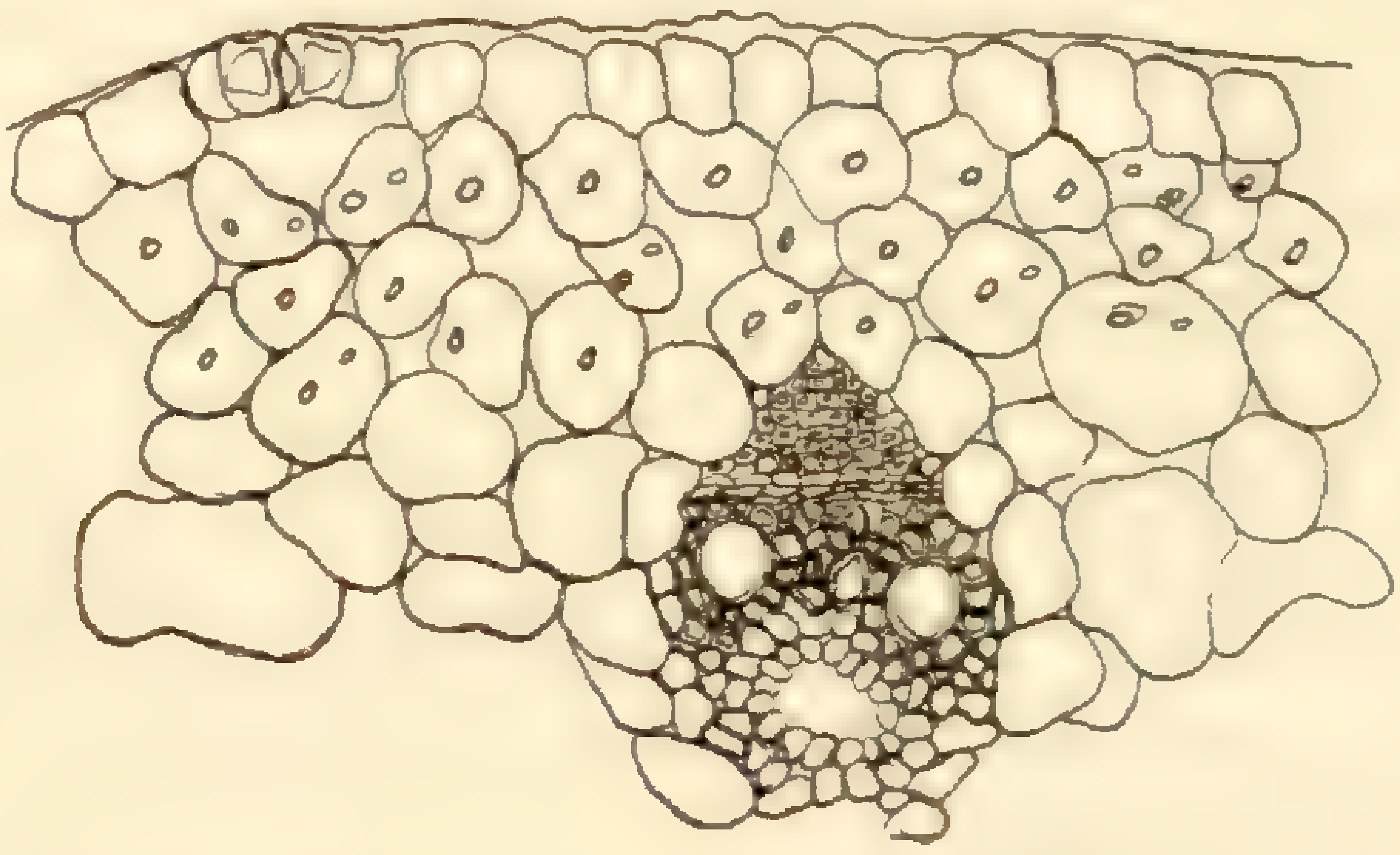

FIG. 3. Partial cross-section of phyllode, hydrophytic form, × 140.

The phyllodes of the submerged plants possessed in all cases the same structure as those grown under the bell-jar and exhibited an additional modification in their method of propagation. New plants were developed from the nodes of the xerophytic stems which had been developed before the plants were submerged and also in turn from the nodes of plants produced under water.

The water in which the immersed plants were grown presented none of the difficulties of absorption of the liquid in bogs. These submerged individuals as well as those in the bell-jars were seen to undergo true aquatic adaptations consisting in the loss of hypoderm of the central stellate tissue and of the glands; the reduction of the chlorophyl-bearing elements, of the endoderm, and of the number of stomata as well as of the xylem; the change in the position of the resin duct; the modification of the epidermal cells, stomata, cells of the septa and the course of the bundles through the septa; and the adoption of a new method of propagation.

These changes may be divided naturally into two classes, those which involve a suppression of xerophytic characters and those which are a means of adaptation to moist conditions and therefore hydrophytic in their nature. In the first class we must consider the loss of hypoderm and glands, the reduction of palisade-cells and water-storage tissue of the endoderm and the loss of cuticle; while we find in the modification of the epidermal cells, the reduction and modification of the stomata and the adoption of a new method of propagation types of structure peculiarly distinctive of hydrophytes. If the action of water free from high concentration of osmotic substances will induce such sweeping departures from the normal, it seems but reasonable to conclude that the plant is naturally a swamp xerophyte.

The adaptations described seem to have been most thoroughly adopted by the species since the characteristic structure of the phyllodes is to be found in the seedlings. These seedlings were raised from seed developed by the plants with which the experiments were made. The cotyledons were flat and linear in shape and 5 to 6 cm. in length. When the first leaf developed it exhibited the typical awl-shaped, septate character and bore glands and the accompanying scales along one side throughout its length. In internal structure it also resembled the later leaves in all respects, except that the hypoderm was absent and that the cells of the endoderm bore chlorophyl.

The chief results of importance brought out in the foregoing paper may be briefly summarized as follows:

1. The leaf-structures of *Oxypolis filiformis* are terete, awl-pointed phyllodes with numerous septa or diaphragms, and this form is exhibited even by the first leaf of the seedling. The

structure of the septa as examined by myself differs notably from that described by Briquet.

2. The phyllodes normally bear numerous glands sunk in pits which are edged with a minute scale. These glands are on a line at 90° from the plane of the stipules and the attendant scales may not be considered as vestigial leaflet structures as suggested by Goebel as to the scales of *Crantzia*.

3. Plants of *Oxypolis filiformis* when grown in a saturated atmosphere or under the influence of normal soil-water (submerged) exhibits marked hydrophytic adaptations of the phyllode. The changes ensuing under such circumstances emphasize still further the xerophytic character of the phyllodes as indicated by their anatomical character, and reënforce the conclusion that this species should be regarded as a swamp xerophyte.

Some common Types of Lichen Formations

BY BRUCE FINK

In a paper published about three years since by the Torrey Botanical Club, I referred to the lack of adequate consideration of the ecologic distribution of lichens and attempted to outline briefly some of the interesting questions which may well claim the attention of lichen collectors. It is my purpose in this paper to take up some of the ecologic factors there suggested and follow them out in considering four or five of the more common types of lichen formations that have come to my notice in field work.

In attempting such a presentation I am well aware that there is much yet to be ascertained concerning the influence of physical structure and chemical composition of substrata upon lichen distribution. It is well known that those foliose lichens which have rhizoids are especially adapted to rough and loose surfaces, while the smoother and more dense surfaces usually bear lichens having more rudimentary crustose thalli. As to the influence of chemical composition of substrata in determining the composition of lichen formations, M. Fünfstück has studied the fatty secretions of calcareous rock-lichens and finds that these fats are probably utilized by the plants for nutrition. Hence, as these plants seem to build up fats from the carbonates of the rocks, they would doubtless have an advantage over other lichens in the struggle for possession of the calcareous rocks. That these and other rock-lichens secrete acids that cause the rocks to decay, rendering them easy of penetration, is well known, and G. Lindau finds that crustose bark-lichens act in much the same way in gaining possession of the smooth bark on which they commonly grow.

To what extent these lichens utilize the elaborated sap of the tree for nutrition we do not know, and definite knowledge in this matter would assist greatly in ecologic studies. In general, lichens are known to produce certain chemical compounds, varying more or less with the nature of the substratum. In what degree these compounds are of use to the plants and to what degree they are derived from the substratum are little known. Till these problems are solved, we can hardly hope to discuss very intelligently chemical composition of substrata as an edaphic factor.

On the other hand the anatomical structure of lichen thalli is fairly well known, so that structural adaptations may be more intelligently considered. Moreover, a large amount of observation has shown conclusively that many lichens commonly occur upon substrata of quite varied chemical composition and physical structure provided the conditions of light and moisture are favorable. Therefore, all things considered, the structural adaptations of lichens to these conditions must for the present receive chief attention in any consideration of lichen formations.

With this much of preliminary statement, I shall follow out the consideration of four or five of the commoner kinds of lichen formations. Doubtless the first to present themselves to the average collector would be what I have, in my studies of the Minnesota lichens, seen fit to call the *Parmelei formations of trees with rough bark* and the *Pyrenula formations of trees with smooth bark*. The lichens composing these formations are the ones best known and most collected, and I shall not reproduce here the rather laborious list of plants most commonly found in them, such lists having already appeared in the Minnesota Botanical Studies. However, the lichens growing more or less commonly on rough bark vary widely as to structural adaptations. The typical members of such formations are the species of *Parmelia* and their near relatives in *Theloschistes* and *Physcia*. The lichens of these three genera commonly have foliose thalli, not very closely adnate, and possessing rhizoids for attachment and support and secondarily for absorption of moisture. These thalli have good cellular cortices on all sides, serving both for support and for protection against excessive evaporation. Scarcely less at home in these formations are the fruticose species of *Ramalina* and *Usnea*. These plants also have well-developed cortices, which serve for protection against excessive evaporation and also give mechanical support so that the plants are able to rise from the substrata or to hang in pendulous fashion. The foliose species of *Leptogium* with thin upper cellular cortices only, seek damp places in the formations and the species of *Collema* devoid of cellular cortex, yet more moist habitats.

Of the lichens of the smooth bark formations, the species of *Py-*

renula are most representative. These plants have very rudimentary thalli, consisting mostly of a network of hypophloeodal hyphae in which are entangled the algal cells. In gaining a foothold, the hyphae seem to work their way between the decaying cells of the bark, and, once firmly established below the surface, the bark itself furnishes both protection and support, as well as moisture. After *Pyrenula* the species of *Graphis* and *Arthonia* contain the next most typical members of smooth bark lichen communities. In these two genera, the thalli are of essentially the same structure as in *Pyrenula.*

The crustose species of *Biatora*, *Buellia* and *Lecidea* all have small thalli devoid of cellular cortices. But these plants have, as is commonly true of the more rudimentary epiphloeodal thalli, an upper colorless network of hyphae devoid of living algal cells and tending to lie in a horizontal direction. These hyphae, together with a number of entangled dead algal cells, form more or less of a protection to the living algae below. The lichens having such thalli may be looked for in either the smooth or the rough bark formations, and the same is true of certain species of *Lecanora*, *Placodium* and *Pertusaria* which have larger thalli, possessing at least some indication of upper cortex.

In the above statements I have had in mind the bark formations of our common deciduous trees, and such lichen assemblages may be looked for wherever these trees exist in considerable numbers in forests. Yet no American has seriously studied the relations of epiphyte or parasite to host, though statements may be found in scattered writings regarding the occurrence of certain lichens upon a given species of tree. In Europe, F. Arnold, in his systematic studies of the lichen flora of Munich, Germany, and of that of the Jura Mountains, has exhaustively recorded the lichens growing upon each species of tree and has extended the study to other substrata than trees. This is interesting, especially regarding those lichens that are confined to a particular host or substratum, but Dr. Arnold has left practically untouched the more interesting and obscure problem of the adaptations of the lichens to these substrata.

Passing from these lichen formations of the trees, let us next give attention to what appear to be the next most easily observed of lichen formations of our northern prairies, viz., those of the bowlders. I shall give a list of the lichen species most commonly occurring in such formations and shall designate the formations thus:

THE LECANORA FORMATIONS OF EXPOSED BOWLDERS

Physcia stellaris (L.) Tuck.
Physcia caesia (Hoffm.) Nyl.
Placodium cerinum sideritis Tuck.
Placodium vitellinum (Ehrh.) Naeg. & Hepp.
Lecanora rubina (Vill.) Ach.
Lecanora varia (Ehrh.) Nyl.
Lecanora cinerea (L.) Sommerf.
Lecanora fuscata (Schrad.) Th. Fr.
Rinodina sophodes (Ach.) Nyl.

This short list includes only about one third or one fourth of the lichens that may commonly occur in the formation in a locality where it is well developed; but the few given may be looked for in any favorable locality in the northern United States, and the addition of other species would scarcely show any greater amount of variation as to adaptations. Indeed, it will be sufficient to consider the adaptations of the genera of the above list rather than those of each species. The species of *Lecanora* and *Placodium* are the most characteristic plants of such formations. The species found on exposed bowlders are nearly all strictly crustose and closely adnate, so that moisture is confined in the substratum below the thallus and readily absorbed. The larger species of *Lecanora* usually have well developed upper cortices for protection against excessive evaporation. The species of *Placodium* have upper cortices more or less developed, and some of the species have such structures below as well. The species of *Physcia* are foliose, but closely adnate; and those commonly found in these exposed formations have well developed cellular cortices on all sides. *Rinodina* has a small thallus, consisting of a tangle of hyphae enclosing the algal cells and protected only by the upper more or less horizontal layers of hyphae and the entangled dead algal cells. In general, those plants of such formations which have no upper cortices have very small thalli, while those having the cortical protection and support may attain a quite considerable size even in their exposed habitat. A large foliose lichen devoid of cellular cortex, as a *Collema,* could hardly exist in the formation. Finally among the lichens of such formations are a few foliose species with well-developed cortices on all sides, but still closely adnate; and a much larger number of crustose forms which have upper cortices only or none, and which, though epilithic, are closely adnate and have small thalli.

I have recorded from some Minnesota localities what I have called *The Mixed formations of shaded bowlders.* I cannot discuss these rarer formations within the limits of this paper, but merely wish to refer to them as being quite distinct from the exposed bowlder formations. Finally, before leaving this portion of the subject, I may state that the formations of extended rock exposures will not be found to differ greatly from those of the closely related bowlders, except where influenced by climatic conditions due to proximity to large bodies of water along the coasts or on the shores of the great lakes, or to high elevation in the mountainous regions.

The three classes of lichen formations thus far discussed are the ones which may be most easily investigated in the field, and yet there are two more types which are so easily studied in many parts of our territory that I am disposed to give them some attention. I refer to the formations of exposed calcareous earth and to those of exposed calcareous pebbles or horizontally exposed limestone. In a previous study, I have designated the first of these formations thus: *The Biatora decipiens formations of exposed calcareous earth.* These formations are remarkably constant as to the elements composing them wherever I have observed them in Minnesota, Iowa and Illinois, and are likely to contain the species listed below, and few if any others, wherever well developed in the northern states. The list of species is:

Heppia Despreauxii (Mont.) Tuck.
Urceolaria scruposa (L.) Nyl.
Biatora decipiens (Ehrh.) Fr.
Biatora decipiens dealbata Auct.
Biatora muscorum (Sw.) Tuck.
Endocarpon hepaticum Ach.

These formations are commonly best developed on hillsides where the plants are washed by lime-impregnated water which flows down the slope during rains. As to structural adaptations to an exposed and usually dry environment, the plants all have small thalli and are closely adnate. The thallus of *Biatora muscorum* (Sw.) Tuck. is very small and devoid of cortex. That of the *Urceolaria* is somewhat larger and has a pseudo-cortex above. The other larger thalli furnish good protection to the algal cells within, that of *Biatora decipiens* (Ehrh.) Fr. having a very heavy cellular cortex above, that of *Endocarpon* being provided on all sides with a well-developed cortex while that of the *Heppia* is cellular throughout. These cellular areas of the larger thalli serve of course not only for protection against excessive evaporation, but also for support. It must be said that none of the thalli of this formation are really large, those of the three last considered averaging from 3–6 mm. in diameter. Indeed a large lichen thallus found in such a formation would needs be considered as an accident in distribution.

Closely related to the formations of calcareous earth and usually occurring with or near them, are those of the calcareous pebbles or horizontally-disposed calcareous rocks. Taking the name partly from a lichen which I have thus far never failed to find whenever the formation is well developed and giving a list of species commonly found in such formations, we have the following:

THE LECANORA CALCAREA CONTORTA FORMATIONS OF EXPOSED HORIZONTAL LIMESTONE SURFACES (OR OF LIMY PEBBLES)

Placodium vitellinum aurellum Ach.
Lecanora calcarea contorta Fr.
Lecanora privigna (Ach). Nyl.
Endocarpon pusillum Hedw.
Verrucaria muralis Ach.

These formations are less constant as to floral elements than those of calcareous earth and when well developed usually contain several variable elements not given in the above list. The lichens composing such formations have small thalli, closely adnate or even more or less strictly hypolithic. All except the hypolithic

Verrucaria and *Lecanora privigna* (Ach.) Nyl., which has a very evanescent as well as rudimentary thallus, have more or less developed cellular or pseudo-cellular cortices above. These upper cortices give the small thalli sufficient protection against evaporation, thus adapting them to their xerophytic habitat.

The occurrence of the fatty secretions in some of the lichens of the last two formations should be noted as an adaptation to their calcareous substrata. Also it may be stated that all but one of the types of lichen formations recorded in this paper are essentially xerophytic, for I suppose that the lichen formations on rough bark in mesophytic woods may be regarded as xerophytic at least as regards the more typical foliose and fruticose members. The one exception is the formations of the smooth bark, at least when borne hypophloeodally on trees with living bark so that moisture passes readily from the trees to the lichens growing upon them.

The five types of lichen formations considered in this paper have been selected from some twenty-five that I have observed in the field. Ecologic distribution of lichens is an extremely interesting field of botanical study, and my object has been to indicate, by preliminary statement followed by application to some common types of formations, what may be accomplished in this line by careful investigation.

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AUGUST, 1903

The Polyporaceae of North America.—V. The Genera Cryptoporus, Piptoporus, Scutiger and Porodiscus

By William Alphonso Murrill

The most important groups of the genus *Fomes*, as this term is generally used, have been treated in the preceding papers of this series. The plants heretofore considered are, for the most part, perennial, with large stratified sporophores which grow conspicuously upon the dead or dying wood infested by their very active mycelium. The present paper deals chiefly with species found under the genus *Polyporus* in Saccardo. These plants are annual and their fruit-bodies are less conspicuous than those of the former group, while their mycelium is usually comparatively limited in extent. Most of the species here discussed are terrestrial and somewhat fleshy, being allied to the Boletaceae. These terrestrial species are exceedingly rare and beautiful in North America, and present an interesting problem in distribution. The genus *Porodiscus* introduces the wood-loving forms of the genus *Polyporus*, which will form the subject of another article.

Cryptoporus Shear, Bull. Torrey Club, **29**: 450. 1902

The name *Cryptoporus* was first used by Peck (Bull. Torrey Club, **7**: 104. 1880) to designate a new section of the Placodermei made necessary by the discovery of a species of *Polyporus* having a volva. His description of the section is as follows:

"Pileus at first subcarnose, becoming harder or corky, sessile or stipitate, the margins greatly prolonged beyond and beneath the

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mouths of the pores and wholly or partly concealing them from view, generally opening beneath by a small aperture; pores not stratose, the dissepiments thickened at the mouths and there differently colored."

In raising this section to generic rank, Shear cites Peck's description and the description of the single species contained in the section following, with a brief discussion of varieties and several additional collections from new localities.

CRYPTOPORUS VOLVATUS (Peck) Shear

Polyporus volvatus Peck, Rep. N. Y. State Mus. **27**: 98. 1877.
Polyporus obvolutus Berk. & Cooke, Grevillea, **7**: 1. 1878.
Fomes volvatus Cooke, Grevillea, **13**: 119. 1884.
Cryptoporus volvatus Shear, Bull. Torrey Club, **29**: 450. 1902.

This peculiar plant was described from specimens collected on *Abies nigra*. It is also found rarely on *Abies balsamea*, but seems to prefer species of pine, upon which it is quite common. I have seen dead trunks of *Pinus rigida* filled with the mycelium, the fruit bodies emerging through holes made by beetles. It is possible that the specimens found on charred wood in the West are larger than our Eastern plants because no effort is required to reach the surface through a heavy layer of cortex. Torrey's stipitate Western form figured by Gerard is duplicated at times in the East when the plant grows on the top of a log. Henning's variety *Helix* from California is fully described by Peck and differs in no way from the type, which had not been seen when the variety was described. Peck's varieties *obvolutus* and *Torreyi* seem hardly worthy of separation. *P. evolvens* Berk. & Cooke, Herb. Berk. 1879 from California, fastened to a sheet of *P. evolutus* B. & C., is only *P. volvatus* and is very distinct from *P. evolutus*.

EXSICC.: California, *Harkness*, *Torrey*, *McClatchie*; Colorado, *Crandall*, *Shear & Bessey*; Oregon, *Shear*, *Carpenter*; West Virginia, *Nuttall*; New York, *Murrill*; Michigan, *Robbins*; British Columbia, *Macoun*; Delaware, *Commons*; District of Columbia, *Shear*, *Hicks*.

PIPTOPORUS Karst. Rev. Myc. 3: 17. 1881

This genus was originally established upon a single species, *Polyporus betulinus* (Bull.) Fr., and has since remained monotypic.

It is chiefly distinguished from nearly related genera by its separable hymenium, which, upon investigation, is found to be cut off from the context proper by a thin flesh-colored layer of mycelium connected very loosely with the adjacent layers and allowing them to separate easily. In age this layer disintegrates and the tubes fall away in irregular masses, leaving the smooth white surface of the context conspicuously exposed.

PIPTOPORUS SUBEROSUS (L.) Murrill

Boletus suberosus L. Sp. Pl. 1176. 1753.
Boletus betulinus Bull. Herb. France, *pl. 312.* 1786.
Polyporus betulinus Fr. Syst. Myc. **1**: 358. 1821.
Piptoporus betulinus Karst. Rev. Myc. **3**: 17. 1881.
Piptoporus suberosus Murrill, Jour. Myc. **9**: 94. 1903.

Pileus fleshy to corky, compressed ungulate, convex above, plane below, attached by a short umbo behind, varying to bell-shaped when hanging from horizontal trunks, 5–30 × 5–20 × 2–5 cm.; surface smoky, covered with a thin separating pellicle, glabrous, devoid of markings, cracking with age; margin velvety, concolorous, obtuse, projecting beyond the hymenium nearly a centimeter: context fleshy-tough, elastic, homogeneous, 3 cm. thick, milk white; tubes separated from context by a thin pink layer, 0.5 cm. long, 2–3 to a mm., sodden white; mouths very irregular, dissepiments thicker than pores, obtuse, entire, crumbling away in age, leaving the smooth white context: spores white, cylindrical, curved, 4–5 μ in length.

This plant is confined to species of birch, upon the dead or decaying trunks of which it is quite abundant in the northern United States and Canada. Its common occurence in Sweden explains why it was noticed and described by Linnaeus in Flora Suecica as early as 1745. From the following selected exsiccati it will be seen that this species is as cosmopolitan as its hosts. France, *Roumeguère 2102;* Germany, *Sydow 627;* Saxony, *Krieger 907;* Sweden, *Romell 10, Murrill;* Russia, *Jaczewski 76;* Wisconsin, *Baker;* New Jersey, *Murrill;* New York, *Underwood, Murrill;* New Hampshire, *Miss Minns, Grout.*

SCUTIGER Paul. Icon. Champ. *pl. 31. f. 1–3.* 1793

Seven species were included in this genus by Paulet, one of them an agaric, four hydnums and two polypores. The first species listed and described is *Scutiger tuberosus* Paul., later changed to *Polyporus asperellus* by Leveillé, a well-known European species belonging to the section *Ovini* of Fries and to the genus *Polyporus* of Karsten and *Caloporus* of Quélet. *Albatrellus* of S. F. Gray, another synonym of *Scutiger*, antedates the two last mentioned by more than half a century. Plants belonging to this genus are central-stemmed, fleshy-tough and terrestrial with white flesh, rounded pores and smooth, hyaline spores. Some of the members of this group approach the closely related genus *Boletus*, but are firmer, tougher and more lasting.

As to distribution, the species of *Scutiger* are, in general, limited to rather small areas; few of them are common, some are rare and local, and, so far as known, European and American species are entirely distinct. The indications are that the plants lack vigor and are easily affected by soil, climate and other environmental conditions. *Polyporus poripes* Fr. was placed in this group before the plant was fully known. Mature specimens show that it belongs rather with multiplex forms such as *Polyporus frondosus* under the genus *Grifola*. A somewhat older stage of *P. poripes* was described by Berkeley and Ravenel in 1872 as *P. flavovirens*.

Synopsis of the North American Species

1. Surface of pileus uneven, squamose or rugose. 2.
Surface of pileus smooth, tomentose or glabrous. 4.

2. Pileus sulfur-yellow, pleuropus, surface ornamented with imbricated floccose wart-like scales, context white or yellowish, tubes small, angular, decurrent, white, becoming greenish when wounded, yellowish when dry, spores 9 × 6 μ. 1. *S. Ellisii.*
Pileus brown. 3.

3. Tubes large, 1.5 mm. or more in diameter, hexagonal, surface of pileus smoky-brown ornamented with darker imbricated tufts of appressed hairs, context white, stipe excentric, its entire surface reticulate. 2. *S. retipes.*
Tubes small, 0.5 mm. in diameter, polygonal, decurrent, white, pileus reddish-brown, rugose, stipe central, not reticulate. 3. *S. decurrens.*

4. Pileus light-colored, white, red or blue. 5.
Pileus dark-colored, gray or brown. 7.

5. Pileus white, context white, tubes irregular, dissepiments thin, white, plants small, growing upon grass roots, stipe short, dark-brown. 4. *S. cryptopus.*
Pileus red, glabrous, stipe short, concolorous, context rose-colored, tubes short, small, 1–2 × 0.2 mm., decurrent, orange-colored, spores ovoid, hyaline, 4 × 5–6 μ. 5. *S. laeticolor.*
Pileus blue when fresh, changing to brown on drying. 6.

6. Tubes entire, becoming reddish-brown on drying, context ochraceous and pileus and stipe reddish-brown in herbarium specimens. 6. *S. caeruleoporus.*
Tubes lacerate, fading to grayish-brown or dirty white, context nearly white, pileus and stipe dull smoky-brown when dry. 7. *S. holocyaneus.*

7. Stipe black and rooting. 8.
Stipe neither black nor rooting. 9.

8. Pileus smoky-brown, subtomentose, margin thin, inflexed, context white, tubes regular, polygonal, entire, 2 mm. long, 0.5 mm. in diameter, stipe cylindrical, light-brown above, black and rooting below, spores white, elliptical, $7 \times 5\,\mu$. 8. *S. radicatus.*
Pileus drab-colored, nearly glabrous, margin thin, inflexed when young, context milk-white even when dry, tubes white, irregular, toothed, 1 mm. long, 0.25 mm. in diameter, stipe short, sooty-black as far as the decurrent tubes, attached to buried wood, spores white, $3\text{–}4 \times 5\text{–}7\,\mu$. 9. *S. subradicatus.*

9. Pileus gray, glabrous or nearly so, margin very thin, context rosy-gray, soft, fleshy, thin when dry, tubes small, 0.25–0.5 mm., unequal, decurrent stipe short, concolorous. 10. *S. griseus.*
Pileus brown. 10.

10. Stipe dark purple, very thick, pileus fulvous-brown, purplish at times, clothed with short tomentum, margin very obtuse, context reddish beneath the cuticle, marked when dry with a black concentric line limiting growth, tubes white, 2 to a mm. 11. *S. persicinus.*
Stipe yellowish-brown, usually excentric, plants caespitose, pileus yellowish-brown, pruinose, margin thin, context rose-tinted when dry, dark red next to the tubes, which are small, $1\text{–}3 \times 0.3$ mm., decurrent, rose-colored when dry, the edges fimbriate. 12. *S. Whiteae.*

1. **Scutiger Ellisii** (Berk.)

Polyporus Ellisii Berk. Grevillea, **7**: 5. 1878.

Polyporus flavosquamosus Underw. Bull. Torrey Club, **24**: 84. 1897.

This plant was first collected by Ellis in low woods near Newfield, New Jersey. In 1886 only two specimens of it were known to Ellis, the one just mentioned and one collected in South Carolina by Ravenel. In 1897 it was found in Alabama by Mrs. Earle and redescribed by Underwood as *P. flavosquamosus.* The specimen thus described was growing on clayey soil in pine woods and was large and of advanced age, for it was in February that it was found. Very young plants of this species were collected in the same locality by Bradford in December, 1900, which measured over three inches across, emitting when fresh a "strong unpleasant odor." The indications are, judging from the meager knowledge at our command, that this attractive species is at home in the gulf states and grows but sparingly above the Carolinas.

2. Scutiger retipes (Underw.)

Polyporus retipes Underw. Bull. Torrey Club, **24**: 85. 1897.

The type collection of this species was made in Alabama in 1897 by Mrs. F. S. Earle. The plants were found in autumn growing on the ground in pine woods. Collections were made later in Alabama by Earle and Baker. In color and stature this species resembles specimens of *Polyporus ovinus* sent from Upsala to Kew, but the pores are very much larger and the species are very distinct.

3. Scutiger decurrens (Underw.)

Polyporus decurrens Underw. Bull. Torrey Club, **24**: 83. 1897.

This is a very distinct species, about which little is known. The type plants were collected by Dr. Hasse near Pasadena, California, growing in the soil on the side of a cañon. The collection was made in February, 1896, and no new collections of the species have been reported since.

4. Scutiger cryptopus (Ell. & Barth.)

Polyporus cryptopus Ell. & Barth. Erythea, **4**: 79. 1896.

A very distinct and interesting species found by Bartholomew in Kansas attached to dead grass roots in sandy pastures. The name refers to its habit of lying flat on the ground and thus concealing the stipe, in which position the pilei look like small whitish discs.

5. Scutiger laeticolor sp. nov.

A thick central-stemmed plant of rather large size with a smooth red pileus and orange-colored tubes. Pileus circular in outline, depressed at the center, 10 × 10 × 1 cm.; surface glabrous, brick-colored to purplish-red, margin acute, at first inflexed, irregularly undulate: context fleshy-tough, pale rose-colored, homogeneous, 0.75 cm. thick; tubes 1–2 mm. long, 5 to a mm., decurrent, rather dark orange throughout, mouth subcircular or polygonal, dissepiments thin, toothed at times, especially when decurrent: spores ovoid, smooth, hyaline, copious, 4 × 5–6 μ: stipe short, thick, increasing upward, 2 × 1–2.5 cm., resembling the pileus in color, but solid, firm and tough, with darker flesh.

The above description is made from a rather old and somewhat faded dried specimen collected by Underwood in Alabama in

November, 1895, and now in the Underwood herbarium. Although the description is on this account unsatisfactory, the plant is nevertheless very distinct and must be highly attractive when seen at its best. The only other plant of this species that I have seen is one at Kew sent by Ravenel under the name *P. confluens*. This specimen however, does not figure in my description, since I have made no special study of it. Like most of the other members of the genus, this species is doubtless rare and probably confined to the states south of Virginia. The appearance of the stipe indicates that it is terrestrial, growing unattached in soil rich in humus. The name I have chosen for it refers to its brilliant coloring throughout.

6. **Scutiger caeruleoporus** (Peck)

Polyporus caeruleoporus Peck, Rep. N. Y. State Mus. **26**: 68. 1874.

EXSICC.: New York, *Peck*, *Ellis*; Vermont, *Morgan*; North Carolina, *Atkinson*.

This rare and beautiful species is found on the ground in woods during midsummer. In sheltered spots the whole plant is externally grayish-blue in color, the blue fading gradually to gray upon exposure. Specimens have been found with one half of the pileus exposed and faded, while the other sheltered half was normal. In drying, the blue color disappears, being retained longer in the hymenium than in the surface of the pileus. It was from partially faded specimens that the plant was first described. Herbarium specimens in the Ellis collection are fulvous with darker hymenium and ochraceous flesh. How long the grayish-blue color remains after drying I cannot tell.

7. **Scutiger holocyaneus** (Atk.)

Polyporus holocyaneus Atk. Jour. Myc. **8**: 117. 1902.

This species was collected near Blowing Rock, North Carolina, by Atkinson and Troyer in September, 1901. Several plants were found growing gregariously on the ground beneath coniferous trees. When fresh they were entirely blue, but in drying the color changed to dull brown. In this and several other respects the species resembles *Scutiger caeruleoporus*, from which, however, it is quite distinct.

8. **Scutiger radicatus** (Schw.)

Polyporus radicatus Schw. Proc. Acad. Sci. Phila. **4**: 155. 1834.

Polyporus Morgani Peck, Rep. N. Y. State Mus. **32**: 34. 1879.

Polyporus Kansensis Ell. & Barth. Erythea, **4**: 1. 1896.

EXSICC.: Ohio, *Lloyd, Morgan;* Indiana, *Underwood;* New York, *Overacker;* Canada, *Dearness, Macoun;* Kansas, *Bartholomew.*

This species is found from September to November in woody earth or on much-decayed wood about stumps or dead trunks. It is large and conspicuous and is quite easily recognized by its brown cap, large pores and long stipe, which is black and radicate at the base. The species ranges from Pennsylvania north to Canada and west to Ohio and Kansas, where it has been twice renamed. A specimen from Washington agrees with this plant in many respects, but has a darker, rougher pileus and firmer substance, with some differences in pore-structure. I hesitate, however, to describe it as new without more material, since *S. radicatus* is somewhat variable even in its type locality.

9. **Scutiger subradicatus** sp. nov.

A rather large thin plant with light brown almost glabrous surface, small white serrated tubes and short black stipe. Pileus irregular in outline, convex to plane, 12 × 9 × 0.5 cm.; surface fibrillose, drab-colored to isabelline, margin very thin, inflexed when young, irregularly undulate at maturity: context fleshy-tough, 1–7 mm. thick, pure milk-white even when dry; tubes mere areoles at first, short and small at maturity, scarcely 1 mm. in length, 3–4 to a mm., decurrent to the blackened part of the stipe, white, yellowish when dry, mouths polygonal, regular, at length much elongated by confluence or otherwise irregular, edges thin, toothed or fimbriate when mature: spores ovate to ellipsoidal, smooth, hyaline, not abundant, $3–4 \times 5–7\ \mu$: stipe short, thick, central, tapering and attached at the base, sooty-black up to the pores, 4 × 2.5 cm.; context milk-white, firm, fleshy-tough, surface minutely tomentose, rugose-reticulate when dry.

Two young plants of this species were collected by Dearness at London, Canada, in September, 1896, and a finely developed plant was recently found in New York by Mrs. M. L. Overacker. The three plants form a perfect series in development. All grew attached to decaying wood beneath the soil. The pores are not rounded and punctiform when very young, but large and areolate like those of *Merulius*, the short walls being built up from these ridges like the cells of a honey-comb without increasing in diameter. At first glance, one would say that this species is a peculiar form of *S. radicatus*, but a little investigation shows that it is quite distinct. Because of this superficial resemblance, however, I have assigned to it the name given above.

10. **Scutiger griseus** (Peck)

Polyporus griseus Peck, Rep. N. Y. State Mus. **26**: 68. 1874.

Polyporus Earlei Underw. Bull. Torrey Club, **24**: 84. 1897.

EXSICC.: New York, *Peck;* New Jersey, *Ellis, Stevenson;* Alabama, *Earle.*

This species has been found on the ground in open deciduous woods in New York and New Jersey and in pine woods in Alabama. It is the only member of the genus that has been collected in any quantity. Its place in the American flora is very much the same as that occupied by *P. leucomelas* in Europe, though the two species are certainly distinct.

11. **Scutiger persicinus** (Berk. & Curt.)

Polyporus persicinus Berk. & Curt. Grevillea, **1**: 37. 1872.

Little is known of this plant beyond the original description in Grevillea and a longer one by the same authors in the Centuries of North American Fungi. It was first found by Ravenel in South Carolina growing at the base of trunks in pine woods. A study of the type at Kew shows it to be a very distinct species, while its large size and dark brown or purple color must make it conspicuous among related species when seen in the fresh state. While bearing an outward resemblance to *P. Schweinitzii*, its context and pores are white when fresh, changing to gray when dried, and this color is uniform, except for a black line showing in cross-section as a limit of growth for a certain period. The margin of the pileus is very obtuse and lobed or quite irregular from confluence.

12. **Scutiger Whiteae** sp. nov.

A plant of medium size, growing in clusters, with yellowish-brown pileus and tubes that are white when fresh and rose-colored when dry. Pileus subcircular in outline, convex, depressed at the center, 8–12 × 0.5–1 cm.; surface pruinose, velvety to the touch, isabelline to fulvous, margin acute, at first inflexed, irregularly undulate at maturity: context fleshy-tough, 0.2–0.5 cm. thick, of nutty flavor, rose-tinted when dry, dark red next to the tubes; tubes 0.1–0.3 cm. long, 3 to a mm., very decurrent, white when young and fresh, rose-colored when bruised or dried, mouths circular or subcircular, edges thin, fimbriate: spores ovoid, hyaline, smooth, copious, 3.5 × 5 μ: stipe short, usually excentric, enlarged at the base, 3 × 2–4 cm., concolorous, tough: plants caespitose, often confluent at the base, all stages of development being found in one cluster.

A fine collection of this species was made by Miss V. White at Bar Harbor, Maine, in August, 1901. The plant was found growing among moss on a damp river bank and seemed to her to resemble *Hydnum repandum* in general habit. Accompanying the specimens are excellent field notes and drawings in water colors.

Plants sent to Kew as *P. ovinus* by Farlow from New Hampshire seemed to me to agree with Miss White's specimens, but no special study of them was made. A few other stray American plants in foreign herbaria lead me to think that this species may possibly range as far south as Ohio, but that its proper home is in New England.

Porodiscus gen. nov.

Hymenophore small, annual, tough, epixylous, erumpent from the lenticels of dead branches; stipe attached to the vertex of the pileus, usually curved at maturity; context white, fibrous, tubes cylindrical, short, one-layered, mouths constricted; spores globose, smooth, hyaline.

The type of this genus is *Polyporus pocula* (Schw.) Berk. & Curt., first described by Schweinitz as *Peziza pendula* and later as *Sphaeria pocula*. By Fries it was first assigned to the genus *Cyphella* and later formed the basis of the new Friesian genus *Enslinia*, which name, however, was preoccupied by *Enslinia* Rchb. The fruit body matures slowly and resembles a discomycete in its early stages, hence the confusion in regard to its systematic position. The name I have chosen for the genus refers to this resemblance. There is only one species known.

Porodiscus pendulus (Schw.)

Peziza pendula Schw. Syn. Fung. Car. 92. no. 1183. 1818.

Cyphella pendula Fr. Syst. **2**: 203. 1822.

Sphaeria pocula Schw. Proc. Acad. Sci. Phila. **4**: 189. *pl. 2. f. 6.* 1834.

Enslinia pocula Fr. Summ. Veg. Scand. **2**: 399. 1849.

Polyporus pocula Berk. & Curt. Proc. Am. Acad. Arts & Sci. **4**: 122. 1859.

Polyporus cupulaeformis Berk. & Curt. Grevillea, **1**: 38. 1872.

This species has been much confused because of its similarity to members of other groups. Schweinitz at first called it *Peziza digitalis* Alb. & Schw. (Consp. Fung. 315, no. 943. *pl. 5. f. 1.* 1805), a European plant which it outwardly resembles, but in publishing it he adds "nisi nova, minor, durior, *pendula* a me nominata." That this name *pendula* was unpublished previous to this time is indicated by the fact that he cites this as the place of its publication under *Cyphella pendula* in Proc. Acad. Sci. Phila. **4**: 184. 1834. That it was in common use may be judged from the fact that Fries got it in manuscript from Schwaegrichen, a friend of Schweinitz and the editor of his work on the fungi of Carolina.

When Schweinitz received more mature specimens of the same species from Dr. Torrey collected on branches of ash, he named it *Sphaeria pocula*, at the same time stating that the plant was entirely similar to his *Cyphella pendula*, except for the presence of perithecia. A southern form on sumac was later named *Polyporus cupulaeformis* by Berkeley and Curtis. The confusion that has arisen is partly due to the small size of the plant and the changes that take place in it as it develops. On emerging from the bark of its host it is erect, sessile and depressed at the center without the appearance of a *Polyporus.* Later, the central depression is occupied by a porous hymenium and a stipe develops, which varies in length and is more or less curved according to its position on the branch. The surface could hardly be called tomentose, but is uniformly covered with a brown powder, which bleaches and partly disappears in age.

As to locality and host, this species shows little choice, being found on dead branches of chestnut, oak, hickory, sumac, red cedar and other trees from New England to Florida. I have found it very common on dead branches pruned from chestnut trees in the woods and parks about New York City. Some of these branches are entirely infested with the fungus, even to the smallest twigs. According to Schweinitz, it was also common on chestnut around Bethlehem, Pennsylvania.

Specimens examined: Rav. Fung. Car. 10, 210, Ell. & Ev. N. A. Fung. 308, 2728, Rabenhorst-Winter Fung. Eur. 3328 (from America); Georgia, *Ellis;* South Carolina, *Ravenel;* Florida, *Calkins;* West Virginia, *Nuttall;* Missouri, *Demetrio;* Pennsylvania, *Ellis;* New Jersey, *Ellis*, *Murrill;* Delaware, *Commons;* Connecticut, *Thaxter.*

NEW YORK CITY.

Bromeliaceae Nicaraguenses Novae

Carl Mez

Catopsis Bakerii Mez sp. nov.

Foliis bene acutis, in caudulam impositam desinentibus; scapi erecti vaginis foliaceis, internodia superantibus; inflorescentia paupere subdenseque 2-pinnatim panniculata; bracteis primariis quam ramuli axillares brevioribus, inferioribus flores infimos attingentibus; bracteis florigeris patentibus, quam sepala permulto brevioribus; floribus fere absque dubio dioicis; sepalis asymmetricis; stylo brevissimo.

Epiphyta, acaulis, florifera ± 0.3 m. alta. Folia ± 7, ad 0.18 m. longa, super vaginam ± 18 mm. lata, lingulata. Inflorescentia subpauciflora, bene virens, glaberrima, ± 100 mm. longa, non nisi ♀ et fructifera cognita; ramulis suberectis vel infimis suberecto-erectis, ultra medium sterilibus, usque ad 50 mm. longis; bracteis primariis suberectis, inferioribus vaginis scapalibus isomorphis; bracteis florigeris naviculari-concavis, latissime ovatis, apice rotundatis et hic brunnescenti-maculatis. Flores suberecti, ♀ vix infra 7 mm. longi; sepalis subcoriaceis, glabris, vix venosis, latere tecto in alam maximam productis. Capsula ex ovoideo breviter rostrata, ± 10 mm. longa, seminum lanâ pallide ferrugineâ.

Nicaragua, dept. Granada in vulcano Mombacho, arboribus sylvestribus epiphyta: C. F. Baker, no. 2460. — Fructificat Februario.

Obs. — *Catopsi Morrenianae* Mez affinis, imprimis inflorescentiae spicis abbreviatis et bracteis sat minoribus nec non habitu diversa.

Tillandsia (§ *Platystachys*) **orthorhachis** Mez et C. F. Bak. sp. nov.

Foliis utrinque lepidibus pallidis adpressis obtectis praesertim subtus cinerascentibus, persensim acutis; inflorescentia paupere panniculata e spicis ± 6 laxiusculis, pinnatis composita; bracteis florigeris stricte erectis, haud vel vix imbricatis, axes omnino rectos haud obtegentibus, dorso glabris et manifeste venoso-lineatis, apice acutiusculis, sepala longe superantibus; floribus stricte erectis; sepalis subaequaliter liberis.

Acaulis, florifera metralis. Folia utriculatim rosulata, basi in vaginas magnas, ovales, dense lepidibus inferioribus immersis, centro late brunneis margine pallidis consitas dilatata, ± 0.35 m. longa, super vaginas ad 25 mm. lata, inde in apicem eleganter recurvum, crasse subuliformem persensim angustata elongatissime subtriangularia, sicca rigida. Scapus folia longe superans, validus erectusque, dense vaginis inferioribus in laminas subulatas recurvas desinentibus superioribus haud laminigeris apice acutis, erectis adpressisque, internodia superantibus involutus. Inflorescentia submultiflora, laxe 2-pinnatim e spicis sat elongatis, linearibus, usque ad 140 mm. longis, basi prophylla compluria bracteiformia gerentibus composita, folia perlonge superans, ± 250 mm. longa; spicis 8–14-floris, suberecto-erectis, axibus nullo modo undulatis vel geniculatis, valde angulatis, glabris; bracteis primariis omnino vaginis superioribus scapalibus isomorphis, quam spicae permulto brevioribus, ramuli axillaris basin haud involventibus; bracteis florigeris ± 15 mm. distantibus, praeter marginem anguste membranaceum coriaceis, nullo modo carinatis, explanatis anguste ellipticis, intus glabris, ± 20 mm. longis et 7 mm. latis. Flores stricte erecti, rhachi adpressi, pedicellis brevibus (vix 3 mm.) angulatis stipitati; sepalis 12 mm. longis, anguste ellipticis, apice rotundatis, glabris, prominulo-venosis, subcoriaceis. Capsula ad 35 mm. longa, subcylindrica angulis 3 rotundatis, bene acuta.

Nicaragua, dept. Chinandega, prope Realejo, arboribus epiphyta: C. F. Baker, no. 2092.— Fructificat Januario.

Obs. — Species perinsignis, absque dubio *Tillandsiae adpressiflorae* Mez Guyanensi characteribus proxima, habitu magis ad *T. utriculatam* L. accedens, ab omnibus affinibus spicarum rhachibus rectis sat diversa.

Guzmania (§ *Euguzmania*) **Nicaraguensis** Mez et C. F. Bak. sp. nov.

Foliis subtus densiuscule lepidibus peradpressis pallidis conspersis; inflorescentia subpauciflora, simplicissima, dense spicata, apice haud sterili; bracteis membranaceis, haud umbrino-farinosis, explanatis inferioribus late acutiusculis superioribus rotundatis, flores singulos in axillis gerentibus; sepalis ad 3 mm. connatis, nullo modo corollinis.

Epiphyta, acaulis, florifera ± 0.3 m. alta. Folia ad 10 infundibuliformi-rosulata, basi in vaginas manifestas, bene ovales, densissime lepidibus peradpressis brunneis punctulatas dilatata, ± 0.3 m. longa, medio 20 mm. lata, lingulato-linearia, apice peracuta haud pungentia, chartacea, supra saturate subtus pallide viridia. Scapus quam folia multo brevior sed manifestus, erectus, glaber, vaginis subinflatis, ex ovali acutis, erectis, internodia superantibus dense involutus celatusque. Inflorescentia vix 100 mm. longa, per anthesin subfusiformis; bracteis lucide rubris, subinflatis, venoso-lineatis, glabris, siccis paullo nitidulis. Flores saturate flavi, per anthesin bracteas bene superantes, sessiles, 60 mm. longi, strictissime erecti; sepalis 25 mm. longis, anguste conice conniventibus, apice rotundatis, asymmetricis. Petala sepalis ad 33 mm. longiora, ut ex sicco videtur peralte in tubum inferne tenuiter cylindricum superne infundibuliformem coalita demum in lobos ellipticos, rotundatos discreta. Stamina petalis paullo breviora; filamentis alte cum petalis cohaerentibus; antheris brevibus (vix 4 mm. longis), basi sagittatis apice breviter acuminulatis, haud cohaerentibus. Ovarium subpyramidatum in stylum quam stamina multo breviorem sensim angustatum.

Nicaragua, dept. Granada, in vulcano Mombacho, magnis caespitibus arboribus sylvestribus epiphyta: C. F. Baker, no. 2477. — Floret Februario.

Obs.— Species pulcherrima, *Guzmaniae erythrolepidi* Brongn. Antillanae proxima.

Guzmania (§ *Euguzmania*) **platysepala** Mez et C. F. Bak. sp. nov.

Foliis subtus fere omnino glabris; inflorescentia multiflora, simplicissima, densissime spicata, apice haud sterili; bracteis tenuiter membranaceis, glabris, flores singulos in axillis gerentibus; sepalis 15 mm. longis et 8 mm. latis, basi ad 4 mm. connatis, nullo modo corollinis.

Epiphyta, acaulis, florifera ± 0.3 m. alta. Folia subpauca infundibuliformi-rosulata, basi in vaginas manifestas, ovatas, ellipticas, dense immerseque lepidibus alutaceis punctulatas dilatata, ± 0.3 m. longa, medio vix 20 mm. lata, lingulato-linearia, apice peracuta haud pungentia, chartacea, ex sicco vinoso-rubentia. Scapus quam folia multo brevior, validissimus, erectus, glaber, dense vaginis in stirpe typica delapsis indutus. Inflorescentia non nisi fructifera cognita ± 140 mm. longa et 65 mm. diam. metiens, cylindrica, apice obtusa; bracteis fere omnino delapsis sepala certe longe superantibus. Flores suberecto-erecti, sessiles, sepalis fructiferis crasse coriaceis, castaneis, superne leviter venoso-lineatis, glabris, latissime rotundatis, fere symmetricis. Capsula crassa, subcylindrica, bene acuta, ± 35 mm. longa. — Cet. ignota.

Nicaragua, dept. Granada, in vulcano Mombacho, arboribus sylvestribus epiphyta: C. F. Baker, no. 2345. — Fructificat Februario.

Obs.— Species praecedenti absque dubio affinis, fructifera quoque a reliquis *Eu-Guzmaniis* inflorescentiam apicem usque fertilem praebentibus sepalorum forma optime distincta.

The American Species Referred to Thinnfeldia

BY EDWARD W. BERRY

The genus *Thinnfeldia* was established by Ettingshausen in 1852 * to include certain fern-like remains from the European Jurassic, which from their resemblance to the living species of *Phyllocladus* he referred to the Coniferae. Considerable diversity of opinion has since existed as to their true affinity. Thus Schenk considers them members of the Cycadales, while F. Braun refers them to the Filicales, where they are admitted by both Schimper and Saporta, and formerly by Nathorst, though latterly he regards them as Conifers. Potonie (Natürlichen Pflanzenfamilien, 1900) includes the genus among the Filicales of the tribe Pecopterides, but he evidently does not include the American or Arctic species which have been referred to this genus.

In 1874 Oswald Heer described a species from the Cretaceous of Spitzbergen as *Thinnfeldia arctica* (incorrectly spelled *Thinfeldia* by him). Turning to this country we find Lesquereux in 1868 describing a species from the Dakota group as *Phyllocladus subintegrifolius*. Subsequently Heer described apparently identical remains, which were found in considerable abundance in the Atane beds of Greenland, transferring them to the genus *Thinnfeldia* and renaming the species *Thinnfeldia Lesquereuxiana*, classing it under the heading "Incertae sedis" directly following the ferns.

In 1889 Fontaine described three species of *Thinnfeldia* from the Potomac formation of Virginia, including them among the ferns, where they are undoubtedly rightly placed. Additional species from various American localities have been noted or characterized by Newberry, Hollick, Fontaine and Knowlton. It is obvious from the foregoing that the genus is a rather indefinite one not well understood and badly in need of revision, which task I have attempted for the American species. I have not included the European species because of lack of material. Judging from those I have seen figured and from Lesquereux's remarks on others,* I should say that they are correctly classed among the Filicales.

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* Ettings. Abhandl. k. k. Geol. Reichsanstalt, 1^3: no. 3, 2. 1852.

The American species which have been referred to this genus embrace two distinct types of plants. Those from the older Cretaceous beds of Potomac age and from the Triassic apparently represent true ferns comparable with the European type, and since the genus as properly restricted is an old one, not appearing elsewhere after the close of the Jurassic (except for the doubtful *Thinnfeldia variabilis* Velen.) the American Cretaceous species of Fontaine may be regarded as the dwindling remnants of an older flora (only one of his species is at all common or occurs outside of Virginia), thus forming one of the many surviving elements in the Potomac flora that gave it such a decidedly Rhaetic facies. It is quite otherwise with the middle and upper Cretaceous species which have been referred to the same genus. They are all much larger-leaved plants and some of them have a wide distribution. The remains in themselves are unmistakably characteristic, although their true botanical affinity is perhaps not so plain; superficially there is considerable resemblance to the polymorphous filicalean genus *Sagenopteris* from the older Mesozoic of this country and Europe, but this resemblance is only superficial.

Each describer has doubtingly referred his specimens to *Thinnfeldia* as a matter of convenience or precedent rather than from any conviction of relationship with the species from the older formations, and all have noted their resemblance to the existing species of *Phyllocladus*. I have made careful comparisons with the living material available at the New York Botanical Garden and am thoroughly convinced that all of the mid- and late Cretaceous species should be included in the coniferous family Taxaceae. They may perhaps form a link between the Podocarpeae and the Taxeae, and while they are unmistakably related to *Phyllocladus* their extremely large size compared with the existing members of that genus and other minor differences such as petiolate forms and the general absence of crenate margins make it desirable to refer them to a new genus which while indicating their proper relationship shall keep them distinct from the existing small-leaved species. This genus may be designated *Protophyllocladus*, and such additional remarks as may be necessary may well be made in considering the respective species.

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*Fl. Dak. Group, 34.

Protophyllocladus gen. nov.

Comparatively large leaves, of coriaceous texture; linear to ovate-lanceolate in outline; with entire, somewhat undulate, or slightly crenate margins: mostly broader toward the apex: with straight narrowly wedge-shaped base: slightly petiolate: midrib usually stout below, often becoming obliterated toward the apex: secondaries fine, numerous, parallel, occasionally forked, usually buried in the parenchyma of the leaf; they leave the midrib at an acute angle and run directly to the margins.

Constituting well characterized remains ranging from the middle Cretaceous to the basal Tertiary.

Protophyllocladus subintegrifolius (Lesq.)

Phyllocladus subintegrifolius Lesq. Am. Jour. Sci. **46**: 92. 1868; Cret. Flora, 54. *pl. 1. f. 12.* 1874; Fl. Dak. Group, 34. *pl. 2. f. 1–3.* 1892.

Thinnfeldia Lesquereuxiana Heer, Fl. Foss. Arct. 6^2: 37. *pl. 44. f. 9, 10; pl. 46. f. 1–12 a, 12 b.* 1882; Newb. Fl. Amboy Clays, 59. *pl. 11. f. 1–17.* 1896; Hollick, Trans. N. Y. Acad. Sci. **11**: 99. *pl. 3. f. 6.* 1892; Bull. Geol. Soc. Am. **7**: 12–14. 1895; Ann. N. Y. Acad. Sci. **11**: 58. *pl. 3. f. 4, 5.* 1898; **11**: 419. *pl. 36. f. 6.*

Thinnfeldia subintegrifolia Knowlton, Bull. U. S. Geol. Surv. **152**: 228. 1898; Hollick, Bull. N. Y. Bot. Gard. **2**: 403. *pl. 41. f. 13, 14.* 1898.

This is a most wide-spread species, ranging in considerable abundance from Greenland to New Jersey and west to Kansas and Nebraska, in beds of approximately the same age, quite the opposite from what would occur if it represented a waning type.

Originally referred to *Phyllocladus* by Lesquereux, his type figure (*f. 12. pl. 1*, Cret. Flora) is identical in outline with certain leaves of the living *Phyllocladus asplenifolia* Hook. f. (*P. rhomboidalis* Rich.) in which, however, the larger leaves are crenate, while those most like the fossil are somewhat smaller. The resemblance is also markedly close to an undescribed *Phyllocladus* (No. 6282, herb. N. Y. Bot. Gard.) from the Lake Brunner district of the South Island, New Zealand. In this form the leaves are very variable, ranging from nearly simple to almost pinnately parted, some with but the slightest indication of the pronounced crenations of others.

Subsequently discovered remains from Kansas are considerably larger than Lesquereux's type specimen, as are also a number of the Greenland specimens. Some of the Raritan forms have a somewhat different aspect, being long and narrow; sometimes the margins are entire, oftener they are undulate or toothed. Newberry, who examined some hundreds of leaves, so abundant are they in the Raritan clays, says "the aspect which they present is not quite that of any known ferns" and he places them among "Coniferae of Uncertain Affinities." Were the linear form and toothed margins constant features these leaves might be considered specifically distinct, but the specimens show every gradation to forms undistinguishable from those of this species from other localities. *Pl. 11, f. 16,* Fl. Amboy Clays is very similar in all respects to *Podocarpus Nageia* R. Br. from the existing flora of Japan, but there is no resemblance to any other species of *Podocarpus* that I have seen.

An additional locality that may be noted for this species is in the Matawan formation near Cliffwood, N. J.

All these leaves have the aspect of *Phyllocladus*, easily seen but scarcely definable, and except for their large size are strictly comparable, the leaves of *Phyllocladus* showing the same variability of outline as do the fossil leaves.

Protophyllocladus lanceolatus (Knowlton)

Thinnfeldia lanceolata Knowlton, Bull. U. S. Geol. Surv. **105**: 49. *pl. 5. f. 5.* 1893.

This species, which occurs in Montana in beds of Laramie age, is related to the preceding, but is larger, with pointed apex, and according to Knowlton, with entire margin, although his very perfect figure shows slight and wide crenations. He considers it to be closely allied to the existing genus *Podocarpus*, pointing out its resemblance to *Podocarpus macrophylla* Don, a southeastern Asiatic species, *Podocarpus Rumphii* Bl. and *Podocarpus leptostachya* Bl., East Indian and Malayan species, and *Podocarpus salicifolia* Kl. & Karst., a tropical American species. Specimens of the latter, which seems to be the most similar to the fossil leaf, from St. Kitts and Central America are somewhat smaller, although specimens from the north coast of South America average larger and exactly resemble the fossil leaf in size and outline. They differ, however, as do most of the Podocarpeae, in their very entire margins, their indistinct vertical secondaries and the form of their midrib, which in all species of *Podocarpus* which I have seen, except *Podocarpus Nageia* R. Br. from Japan, is thick and prominently marked to the tip of the leaf, while in the fossil leaf the midrib is obliterated by its dichotomous branching some distance below the apex and the secondaries branch at an acute angle and do not parallel the midrib.

Protophyllocladus polymorphus (Lesq.)

Salisburia polymorpha Lesq. Am. Jour. Sci. II, **27**: 362. 1859 (nom. nudum); Ann. Rep. U. S. Geol. & Geog. Surv. Terr. **1872**: 404. 1873; Tert. Fl. 84. *pl. 6. f. 40, 41.* 1878.

Thinnfeldia polymorpha Knowlton, Proc. Biol. Soc. Wash. **7**: 153. 1892; Bull. U. S. Geol. Surv. **105**: 47. *pl. 5.* [*1*]. *f. 1–4.* 1893. (Not *T. polymorpha* Ettingshausen, 1860.)

Thinnfeldia montana Knowlton, Bull. U. S. Geol. Surv. **152**: 227. 1898; Bull. U. S. Geol. Surv. **163**: 11. *pl. 1. f. 1–3.* 1900.

Fragmentary remains from Nanaimo, Vancouver Island, were named *Salisburia polymorpha* by Lesquereux and were subsequently described and figured for a final report which was never published. He afterward described under the same name specimens from Montana, although not positive of their identity with the Vancouver specimens. Whatever may be the final disposition of the Nanaimo forms, those from Montana are certainly not referable to *Salisburia* (*Ginkgo*), although evidently Coniferous. Lesquereux's type figures (Tertiary Flora, *pl. 60. f. 40, 41*), greatly resemble in both form and venation certain leaves of existing species of *Phyllocladus*, for instance *Phyllocladus asplenifolia* Hook. f., although they are somewhat larger, and the remains referred to this species by Knowlton are still larger and petiolate. This species is closely allied to the two preceding and according to Knowlton is positively related to *Phyllocladus*. It occurs in beds of Montana,* Laramie, and Livingston age.

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* Belly River series, on the Missouri River seven miles below Coal Banks, Montana, in strata which are at least in part synchronous with the Montana formation.

THINNFELDIA Ettings. Abhandl. k. k. Geol. Reichsanstalt, **1**^{3}: No. 3, 2. 1852 (restricted)

Fontaine * gives the following diagnosis, which is very nearly that of Schimper: "Fronds bipinnate or tripinnate; pinnules varying much in size and shape, mostly oblong, ovate-lanceolate or oblong-lanceolate, decurrent and mostly confluent at the base; coriaceous; primary nerve of the pinnules dissolved before attaining the apex into many dichotomous nerves; secondary nerves going off at a very acute angle, diverging in ascending, several times dichotomous." Filical remains from the older Mesozoic.

Thinnfeldia Fontainei nom. nov.

Thinnfeldia variabilis Font. Potomac Flora, 110. *pl. 17. f. 3–7; pl. 18. f. 1–6.* 1889; Font. in Stanton, Bull. U. S. Geol. Surv. **133**: 15. 1895.

Fontaine's name is antedated by *Thinnfeldia variabilis* Velen. (Gymnosp. Böhm. Kreidef. 6. *pl. 2. f. 1–5; pl. 3. f. 12.* 1885), an altogether different species as pointed out by Hollick.† It is fitting that the new name should commemorate the original describer.

This is the most common fern near Brooke, Virginia, and reappears in the Knoxville beds of Tehama County, California, the only species of *Thinnfeldia* at all common in the Potomac or reappearing at any other locality. It is unnecessary to redescribe this species; no one has ever doubted that it is a fern. Though specifically different it closely resembles *Thinnfeldia rhomboidalis* Ett.

THINNFELDIA GRANULATA Font. Potomac Flora, 111. *pl. 26. f. 10–12; pl. 27. f. 1–5, 8; pl. 169. f. 1.* 1889

A rare fern found only near Dutch Gap Canal and near Potomac Run, Virginia, in the Potomac formation. Resembles *Mariopteris muricata* (Schloth.) Zeiller.

THINNFELDIA ROTUNDILOBA Font. Potomac Flora, 111. *pl. 27. f. 6, 7.* 1889

This fern is still rarer than the preceding; it is recorded from Fredericksburg and near Potomac Run, Virginia, in Potomac strata. Resembles *Sphenopteridium dissectum* (Göpp.) Schimper.

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* Potomac Flora, 110. 1889.

† Bull. N. Y. Bot. Gard. **2**: 404. 1902.

THINNFELDIA? RETICULATA Font. in Ward, Older Mesozoic Fl. U. S., Ann. Rep. U. S. Geol. Surv. **20**^{2}: 235. *pl. 22. f. 1, 2.* 1900

Poor remains make this determination only provisional. It is undoubtedly a fern, however, possibly a new genus. The veins are strong and anastomose exactly as in *Thinnfeldia variabilis* Velen. Occurs in the Triassic near York Haven, Pennsylvania.

THINNFELDIA ARCTICA Heer (incorrectly spelled *Thinfeldia*), Fl. Foss. Arct. **3**: 123. *pl. 35. f. 11–16; pl. 36. f. 10b.* 1874

From the Cretaceous of Spitzbergen (Cape Staratschin); included here because of its resemblance to the upper pinnae of *Thinnfeldia Fontainei*, from which it differs only in the pinnules being more rounded at the apex.

THINNFELDIA VARIABILIS Velen. Gymnosp. Böhm. Kreidef. 6. *pl. 2. f. 1–5; pl. 3. f. 12.* 1885; Hollick, Bull. N. Y. Bot. Gard. **2**: 403. *pl. 41. f. 12.* 1902

This species is listed by Velenovsky under "Species Incertae Sedis." While it may not be a fern the venation is not that of a coniferous plant, and it may best be left in this genus provisionally; although in so doing the genus is brought down to the mid-Cretaceous, which is undesirable as this species has nothing in common with the other species and is undoubtedly generically distinct. Hollick's remains from the Cretaceous of Chappaquidick Island, Mass., are indistinguishable from the type.

PHYLLOCLADOPSIS Font. Potomac Flora, 204. 1889

For the sake of completeness in the enumeration of American Phyllocladian remains I append a short notice of the following species.

PHYLLOCLADOPSIS HETEROPHYLLA Font. Potomac Flora, 204. *pl. 84. f. 5; pl. 167. f. 4.* 1889

The thick texture and immersed venation are those of *Phyllocladus*, but the outline and margin are different; the general aspect is decidedly not that of a fern. But for the diverging veins to the margin this species would fall in *Nageiopsis* Font., which is such a striking type in the Potomac flora, with fourteen species, so like the existing *Nageia* section of *Podocarpus*, that Fontaine hesitates in classing them as generically distinct. It curiously illustrates the mixed affinities of these ancient members of the Taxaceae.

The genus *Podocarpus* is abundantly preserved in European strata, Schimper (Pal. Végét.) enumerating nine species; *Phyllocladus* on the other hand has not yet been found, although Heer * describes some curious remains from the Cretaceous of Spitzbergen under the name of *Phyllocladites rotundifolius.*

PASSAIC, N. J.

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* Heer, Fl. Foss. Arct. 3: 124. *pl. 35. f. 17–21.* 1874.

Some Notes on Juncus

By K. M. Wiegand

Since the publiction of a previous paper on *Juncus tenuis* and its allies in the Bulletin for October, 1900, a large amount of additional material has been studied, making some slight changes necessary in the treatment of the group.

The range of *J. dichotomus* is extended westward along the Gulf coast to Texas. Alabama (*Chas. Mohr*); Mississippi (*S. M. Tracy*); Texas (*Nealley*, *Thurlow*, *Wurzlow*).

At the time of the previous publication *J. secundus* seemed confined to the Atlantic coastal plain, and *J. interior* to the Ohio and Mississippi Valleys and the Great Plains. Two specimens from the Mississippi Valley have appeared, however, which can in no way be distinguished from *J. secundus*, and not without considerable hesitation I am compelled to admit the occurrence of this species west of the Alleghanies. The specimens are: Missouri (Desoto, *H. E. Hasse*, 1887), Illinois (*Vasey* in Nat. Herb.). A plant from Lookout Mt. (*Eggert*) seems also to belong to this species.

The range of *J. occidentalis* is extended northward to Vancouver Island.

Specimens of *J. confusus* have now been studied from the following states and provinces: Alberta, Assiniboia, Washington (Spokane), Oregon (Warner Range), Idaho, Montana, Wyoming, Colorado.

J. Georgianus Coville has been found also in North Carolina on Dennis Mt. (*Small*).

Juncus Dudleyi Wiegand extends at least as far northwestward as Washington (Pullman, *E. R. Lake*, no. 175).

Juncus interior occurs in the following states and territories: Illinois, Kansas, Indian Territory, Colorado, Wyoming, New Mexico and Arizona.

Juncus Arizonicus curtiflorus Wiegand appears not to be distinct from *J. interior*. The material at hand when the description was drawn showed sepals slightly longer than the capsule, but this now appears to be not at all constant. The range of *J. interior* is therefore extended into New Mexico and Arizona.

From Arizona and New Mexico other specimens have been received, however, which seem to be quite distinct not only from *J. Arizonicus* but also from all other hitherto described species. It seems best to present these here as follows:

Juncus Neo-Mexicanus sp. nov.

Perennial, 20–50 cm. high, rigid and erect, rather pale green and strongly striate: leaves in well grown plants half the length of the culm or less, flat, moderately narrow (0.5–1.75 mm. wide); sheaths loose, the margins membranous but scarcely scarious, tapering above to the auricles which are membranous and scarcely at all produced: inflorescence small, 2–8 cm. long, usually green even in fruit, not congested, the branches erect; bracts 2–3, at least one much longer than the inflorescence; bracteoles apiculate: flowers green, rather large; sepals 4–5 mm. long, rigid, pungent, strongly spreading, the membranous margins very narrow, all nearly similar; stamens 6, about one half the length of the perianth, anthers short: capsule conspicuously ovate, thick-walled, about $\frac{1}{5}$–$\frac{1}{4}$ shorter than the perianth; placentae not reaching to the axis; mature seeds not seen.

Arizona and New Mexico. Arizona — Huachuca (*E. Palmer*, no. 461*b*, 1890, type, Nat. Herb.), Cedar Springs, "growing abundantly in cool water of spring and outlet" (*J. W. Toumey*, no. 513, July, 1892); Grand Cañon, Yavapai Co. (*E. O. Wooton*, no. 1018, 1892). New Mexico — *E. Palmer*, 1869 (? too young).

Related to *J. Dudleyi* Wiegand and *J. tenuis* Willd., but differing from the former in the loose sheaths with simply membranous receding auricles. The flowers are as large as the largest of *J. Dudleyi* and even more comose in appearance. From *J. tenuis* it differs in the absence of scarious sheath-margins and auricles and in the usually more coriaceous capsule. In specimens at hand the plant has a peculiar rigid appearance, especially in the rigid pungent sepals, which is unlike that of the two related species.

The separation of *Juncus dichotomus* from its allies has always seemed a comparatively easy matter, because the leaves of that plant have been found to be nearly terete in every case and not flattened as in the other closely related species. As was noted in my recent paper on this group, however, specimens from near the northern limit of the species show a distinct flattening of the leaves and therefore a transition toward *J. tenuis.* But in addition plants from much further south appear in the herbaria from time to time having the leaves nearly if not quite as much expanded as in any of the closely related forms. These are very confusing to the student who understands *J. dichotomus* in the old way, and it seems best to separate them under a distinct name. Since they are so exactly similar to *J. dichotomus* in all other respects, and because we know very little regarding how far this condition is due to environment, they have been considered as a variety rather than as a distinct species.

The forms under consideration are therefore to be understood somewhat as follows:

JUNCUS DICHOTOMUS Ell.

Differs from *J. tenuis* and *J. Dudleyi* in the peculiar olive-green color of the dried plant; but especially in the reddish-brown or purple basal sheaths, and the darker inflorescence; from *J. tenuis* also in the firm subcartilaginous rounded auricles, not scarious and prolonged; and from *J. Dudleyi* in the less cartilaginous auricles and normally more expanded inflorescence.

Juncus dichotomus platyphyllus var. nov.

Leaves expanded and flat, otherwise as in the typical form.

Massachusetts to Texas, along the coast. On Staten Island a form occurs only six inches high or less and with densely tufted leaves 1–2 inches long.

Some specimens representing this variety are the following in the Herbaria of Columbia University and the New York Botanical Garden:

Massachusetts, near Boston (*B. D. Greene*, 1829).

New York, Staten Island, old field near New Dorp (*Britton*).

Virginia, Hutton's Branch (*Britton and Vail*); Nansemond Co. (*Britton and Small*, May 27, 1893, type).

North Carolina, Chapel Hill and Bladen Co. (*W. W. Ashe*).

Mississippi, Starkville (*S. M. Tracy*).

CORNELL UNIVERSITY.

A Revision of the Family Fouquieriaceae

By George V. Nash

During an attempt to identify one of the species of *Fouquieria* which flowered in the conservatories of the New York Botanical Garden during the past June, much confusion was found to exist, both in the identification of herbarium material and in the literature bearing upon this family. So great was this confusion that the writer was eventually compelled to extend his examinations beyond the point he had anticipated, and finally realized that a revision of the family was necessary before any definite results could be obtained. No recent treatment, involving a consideration of the species, could be found, and the apparent need of such work encouraged the author to enter upon the following revision, which, it is hoped, will throw some light upon an interesting family and one but little understood. As here regarded, it embraces two genera and seven species, three of which are here described for the first time.

The relationship of the family is rather puzzling, and a satisfactory solution of the difficulty has not as yet been proposed. By Bentham and Hooker (Gen. Pl. **1**: 161) it was made a tribe of Tamaricaceae, and the same treatment was accorded to it by Engler and Prantl (Nat. Pfl. $\mathbf{3}^6$: 298). Subsequently Engler (Nat. Pfl. Nachtr. 251) maintained that the family was better kept separate from Tamaricaceae on account of its oily endosperm and gamopetalous corolla. Its distribution would also tend to confirm this distribution of the group, for Tamaricaceae, with Fouquieriaceae removed, is strictly Old World, while Fouquieriaceae itself is confined to North America, and primarily to its arid regions.

While Engler changed the rank of this family, he indicated no change in its relationship. It is hardly within the scope of a revision of this kind to discuss at length a matter of this nature, but the strong resemblance in many ways to certain forms of the Polemoniaceae cannot be passed by without some comment. In this connection it is well to remember that it was in this family, as a *Cantua*, that the original species was published. The 3-celled ovary, the more or less united styles and the gamopetalous tubular corolla, to the base of which the filaments are slightly adnate, all markedly point in this direction. The spongy central column found in the dehiscing capsules would indicate that the inner edges of the septa unite. A transverse section of the ovary made at this time, and before the septa break away from the walls, would much resemble the condition of things existing in the genus *Gilia,* also found in the same region. The general resemblance of the flowers to those of some of the large-flowered red Gilias is perhaps the most striking feature of the plants. It is true that the sepals in this are distinct, while in *Gilia* they are more or less united, but this is but one character weighing against many others. It would seem to me that the ovarian, placental, style and corolla characters indicate a strong affinity with that family, much stronger than with the Tamaricaceae, to which family, polypetalous in all its other forms as are its immediate relatives, the gamopetalous corolla of Fouquieriaceae does violence.

FOUQUIERIACEAE DC. Prod. 3: 349. 1828.

Shrubs or trees, the trunks simple, columnar and stout, or much branched: branches spine-branching. Spines developed within the petioles of the leaves on the new growth and becoming apparent when these fall. Leaves with the blades flat, entire, or rarely obcordate or emarginate: those on the young growth petioled, the petioles from one half as long as to equalling the blade. Secondary leaves borne in fascicles in the axils of the spines and sessile or nearly so. Inflorescence spicate to paniculate, terminal. Flowers sessile or pedicelled. Calyx of five free imbricated sepals. Corolla yellow or red, hypogynous, the segments united for one half their length or more: tube cylindric, sometimes broadened toward the apex: lobes flat or concave, imbricated in the bud, incurved, erect, spreading, reflexed or enrolled. Stamens ten to fifteen, of unequal length, exserted from the corolla-tube, and adnate to it at the very base: filaments subulate, usually broadened and compressed dorsally at the more or less pubescent base where they are sometimes coherent, sometimes provided with a scale-like appendage near the base: anthers acute at the apex, cordate at the base, elliptic to nearly ovate, introrse, versatile, attached below the middle, 2-celled, the cells opening longitudinally. Ovary 3-celled, the inner edges of the septa united at the base and at the very apex, free in middle, the septa finally uniting by the inner edges and breaking away from the walls, forming a central column attached at the apex and at the base. Ovules 4–6, in two rows, in each cell, borne on the edge of the free portion of the septa. Styles 3, slender or stout, included in or exserted from the corolla, united only at the base or for their entire length. Capsule dehiscing loculicidally, 3-valved, the valves thick and coriaceous. Seeds oblong, compressed, at first broadly winged, the wing finally breaking up into long filaments similar to those on the body of the seed. Albumen thin, oily. Cotyledons flat, oblong to ovate, cordate at the base. Radicle short.

Genera two, both natives of Mexico, one, *Fouquieria*, also found in the adjacent parts of the United States. The *Idria* of Kellogg is often united with *Fouquieria*, but it seems more natural to keep it separate, both on account of habital characters and differences in the flowers. The short stout included styles united for their entire length, yellow flowers and columnar, normally unbranched trunk, justify this treatment.

Styles more or less united, but free at the apex, exserted, the column and branches slender: shrubs or trees with branching trunk: corolla red. 1. *Fouquieria.*
Styles wholly united, stout, short, included, forming a 3-angled stout body: tree with a stout columnar undivided trunk: corolla yellow. 2. *Idria.*

1. FOUQUIERIA H.B.K. Nov. Gen. & Sp. **3**: 452. 1820

Bronnia H.B.K. Nov. Gen. & Sp. **6**: 83. 1823.

Philetaeria Liebm. Vidensk. Selsk. Skr. V. **2**: 283. *pl.* 1851.

Shrubs or trees with spicate or paniculate inflorescence and red sessile or pedicelled flowers. Sepals less than one half as long as the corolla-tube. Corolla red, cylindric to campanulate, the segments united into a tube for one half their length or more, the tube sometimes gradually enlarged toward the apex: lobes from erect to recurved or enrolled. Stamens ten to fifteen, more or less broadened and compressed dorsally at the pubescent base. Styles slender, exserted, united only at the base, or nearly to the apex.

Species six; Mexico and the adjacent parts of the United States.

Inflorescence corymbiform-paniculate. 1. *F. fasciculata.*
Inflorescence conic to elongated paniculate, or spicate.
  Corolla-tube cylindric, several times longer than the lobes.
    Inflorescence spicate. 2. *F. formosa.*
    Inflorescence paniculate.
      Filaments unappendaged: panicle conic to ovate: bushy shrubs or trees.

Corolla-tube 3–4 mm. in diameter: sepals oval: panicle-branches slender. 3. *F. Macdougalii.*
Corolla-tube 5 mm. in diameter: sepals orbicular: panicle-branches stout. 4. *F. peninsularis.*
Filaments with a scale-like appendage near the base: panicle long and narrow: shrubs with long slender simple branches. 5. *F. splendens.*
Corolla campanulate, the tube about equalling the lobes. 6. *F. campanulata.*

1. **Fouquieria fasciculata** (R. & S.)

Cantua fasciculata R. & S. Syst. **4**: 369. 1819.
Fouquieria spinosa H.B.K. Nov. Gen. & Sp. **3**: 452. 1820.
Bronnia spinosa H.B.K. Nov. Gen. & Sp. **6**: 84. *pl. 528.* 1823.
Cantua spinosa Willd.; H.B.K. Nov. Gen. & Sp. **6**: 84. 1823.
Echeveria paniculata Mocino & Sessé; DC. Prod. **3**: 350. 1828.

A tree 4 m. tall or more, with white fragile wood and round glabrous spiny branches. Leaves fascicled in the axils of the spines, obovate-oblong, rounded at the apex or sometimes emarginate, cuneate at the base, glabrous, shining, about 2.5 cm. long and 9–10 mm. wide: panicle terminal, corymbose, much-branched, its branches glabrous: capsule about 1 cm. long: sepals nearly orbicular, about one fourth as long as the capsule: seeds oblong, compressed, the margin membranous-winged, the inner surface concave, the outer convex, brown, glabrous, the wings nearly entire, emarginate at the apex and at the base; episperm thinly membranous, adhering to the endosperm which is thin and fleshy; embryo included, straight, almost as long as the endosperm, compressed; cotyledons leafy, ovate, obtuse, cordate at the base, fleshy; radicle cylindric, somewhat acute, one third as long as the cotyledons.

The above description is drawn from the original in the work of Humboldt, Bonpland and Kunth, cited above. I have seen no specimens of this species, but its corymbiform panicle is unlike that of any of the others. The type material was in fruit only, and was secured at Puente de la Madre de Dios, at an altitude of about 5,280 feet. This place is somewhere in the neighborhood of Mexico City or Actopan, but it has not been possible for me, up to the present time, to locate it more definitely.

It is interesting to note here that this is the type of *Fouquieria*, a monotypic genus at that time, which was based on *Cantua fascic-*

ulata R. & S. (although H.B.K., for no apparent reason, credit it to Willdenow). Subsequently *Fouquieria* was again published, this time being based on an entirely different plant, *F. formosa*, and at the same time *F. spinosa*, alluded to above, was made the type of the new genus *Bronnia*. The genera are, therefore, synonymous, *Fouquieria* taking presence on account of the priority of publication.

2. FOUQUIERIA FORMOSA H.B.K. Nov. Gen. & Sp. **6**: 83. *pl. 527*. 1823.

Echeveria spicata Mocino & Sessé; DC. Prod. **3**: 349. 1828.

Philetaeria horrida Liebm. Vidensk. Selsk. Skr. V. **2**: 283. *pl.* 1851.

A branching shrub 2–3 m. tall, with a racemose inflorescence and large red flowers. Leaves on the new growth 3–4 cm. long, petioled; petiole about one half as long as the blade; blade 2–2.5 cm. long, 10–13 mm. wide, elliptic, apiculate, cuneate at the base: fascicled leaves in the axils of the spines smaller, sessile or nearly so, elliptic, 1.5–3 cm. long, usually less than 1 cm. wide, rounded at the apex, cuneate at the base: spike 1.5 dm. long or less, the flowers ascending: sepals red, 8–11 mm. long, broadly oval to orbicular: corolla red, the tube a little curved, cylindric, about 2 cm. long and about 7 mm. in diameter, the lobes spreading or reflexed, orbicular, abruptly acuminate, 6–8 mm. long: stamens exserted, unequal in length, sometimes twice as long as the corolla, the filaments a little broadened and compressed below, glabrous at the base, then pubescent for a short distance with long ascending hairs, the remainder of the filament glabrous, the anthers oblong-ovate, cordate at the base, acute at the apex, 5–6 mm. long: styles united except at the apex, shorter than the longest stamens, the divisions 3–5 mm. long.

Southern Mexico.

Specimens examined. — Jalisco: Guadalajara, *Pringle 2420*, 1889. Puebla: Tehuacan, *Pringle 6296*, 1895. Mexico: Chiquihuite, *Bourgeau 1120*, 1865–6.

This is quite distinct from any of the other species in its spicate inflorescence. The exact locality from which it was originally secured is not indicated. The specimens cited above would point to the southern part of Mexico as its home. *Philetaeria horrida* Liebm. was obtained in valleys at an altitude of 1500–1800 meters, in the district of Tehuacan, State of Pueblo, from which place Pringle also secured the same plant many years later. Liebmann's excellent plate and description leave no doubt as to the identity of his plant with the one of H.B.K.

3. **Fouquieria Macdougalii** sp. nov.

A much-branched tree, reaching a height of 7 m. and a trunk diameter of 1–2 dm., with bark yellowish green on the trunk and brown on the spiny branches, the spines 1–2 cm. long, and terminal slender panicles of few bright red flowers. Leaves on the new growth 6–8 cm. long, petioled; blade 3.5–4 cm. long and about 1 cm. wide, acute at the apex, and rather abruptly narrowed into a petiole of the same length: fascicled leaves in the axils of the spines gradually narrowed into a sessile base, 3.5–4 cm. long and about 1 cm. wide: panicle slender, 7–10 cm. long, its delicate simple branches widely spreading, the lower ones 3–4 cm. long and bearing 2–4 flowers on slender pedicels which are 1–2 cm. in length and abruptly thickened at the apex: flowers few: sepals broadly oval, about 6 mm. long, the outer two acute, the inner three rounded and apiculate at the apex: corolla about 2.5 cm. long, the tube cylindric, 3–4 mm. in diameter, the lobes broadly ovate, erect, acute, about 5 mm. long: stamens 10, exserted, the filaments red above, white below, broader and dorsally compressed near the base, the interior surface of this compressed portion glabrous, the exterior surface pubescent with long stout hairs which gradually increase in length upward and extend but a short distance on the rounded part of the filament which is glabrous to the summit, the anthers 2–3 mm. long: styles exceeding the stamens, united almost to apex: capsule about 2 cm. long.

Type specimen from living plants, collected at Torres, Mexico, in 1902, by MacDougal, no. 28, which flowered in the conservatories of the New York Botanical Garden in June, 1903.

Sonora and Sinaloa.

Specimens examined. — Sonora: Rayon, *Thurber 952*, 1851; Torres, *MacDougal 28*, 1902; Alamos, *Palmer 306*, 1890; Granados, *Hartman 226*, 1890. Sinaloa: Culiacan, *Palmer 1804*, 1891.

This plant was first secured by Thurber at Rayon, about eighty miles north of the place where it was recently obtained by Dr. MacDougal. Thurber's plant was distributed as *F. spinosa*, from which it differs materially. It is evidently, however, the plant referred to under that name in the preface to Gray's Plantae Novae Thurberianae (Mem. Am. Acad. Arts & Sci. II. **5**: 303). His description of this tree agrees with a photograph of one made by Dr. MacDougal. The trunk arises from the ground for two or three feet, and then divides into crooked branches, the ultimate divisions of which are pendulous.

4. **Fouquieria peninsularis** sp. nov.

Bronnia spinosa Benth. Voy. Sulph. 16. 1844. Not H.B.K. 1823.

A shrub 2–3 m. tall, with a conic panicle and red flowers. Leaves on the new growth 5–6 cm. long, petioled: petiole about 3 cm. long, about as long as the blade: panicle conic, 1.5 dm. long or less, its branches ascending, stout, the lower ones sometimes 4–6 cm. long and usually divided, bearing 2–4 flowers on the ultimate divisions in a rather crowded manner, on short stout pedicels usually less than 5 mm. long: sepals orbicular or nearly so, 5–6 mm. long, apiculate, reddish: corolla red, the tube slightly if at all curved, about 1.5 cm. long and 5 mm. in diameter, the lobes erect or nearly so, orbicular, acute, 5–6 mm. long: stamens exserted, unequal in length, the filaments broadened and compressed at the base, the inner surface of the compressed portion glabrous, the outer surface pubescent with long ascending hairs, the remainder of the filament glabrous, the anthers 3–4 mm. long: styles united except at the apex: capsule fully 2 cm. long.

Lower California and western Sonora.

Specimens examined. — Lower California: La Paz, *Maj. W. Rich*, Dec. 11, 1847 (type); Turtle Bay, *Anthony 144*, July–Oct., 1896; San Bartolome Bay, *Chas. F. Pond*, March, 1889; Calmalli, *Purpus 141a*, Jan.–March, 1898; Cape San Lucas, *Xantus 38*. Sonora: Guaymas, *Palmer 266*, 1890.

Related to *F. splendens*, but distinguished by the absence of the appendage at the base of the filaments, the more open panicle and the larger capsule.

I have ventured to identify the *Bronnia spinosa* of the Voyage of the Sulphur with this plant, as I have seen material from Cape San Lucas, the place from which that plant was secured. The type of this species was secured at La Paz, only about ninety miles north of Cape San Lucas. Bentham describes the filaments as glabrous, a condition unknown in the genus so far as I have examined it. Otherwise his description agrees well with this plant, and as the filaments are pubescent only toward the base the pubescence might readily be overlooked.

5. FOUQUIERIA SPLENDENS Engelm. in Wisl. Mem. Tour Mex. 98. 1848.

Fouquieria spinosa Torr. in Emory, Mil. Reconn. 147, *pl. 8.* 1848. Not H.B.K. 1820.

A branching shrub, the long slender branches arising from near the base, sometimes to a height of 4–6 m., with a narrow paniculate inflorescence and red flowers. Leaves of the new growth 3–5 cm. long, petioled; petiole about one half as long as the blade; blade 2–3 cm. long, 5–7 mm. wide, narrowly elliptic to oblanceolate, acute at the apex, narrowed at the base: fascicled leaves 1–1.5 cm. long, 5–8 mm. wide, narrowly obovate to obcordate: panicles narrow, solitary or several at the apex of the stem, 5–20 cm. long, the branches usually short and with the few flowers crowded: sepals broadly oval to nearly orbicular, 5–8 mm. long, obtuse or rounded at the apex: corolla red, the tube straight, 15 18 mm. long, gradually a little enlarged toward the apex, 4–5 mm. in diameter at the middle, the lobes spreading and recurved or enrolled, broadly oval to orbicular, obtuse at the apex or sometimes apiculate, 4–5 mm. long: stamens exserted, unequal in length, the filaments broadened and dorsally compressed at the base, the compressed portion running out laterally into a scale-like appendage which is pubescent on the upper surface and 0.5–1 mm. long, the inner surface of this broadened portion glabrous, the outer surface pubescent with long stout hairs, the remainder of the filament glabrous; anthers about 4 mm. long, oblong, abruptly acute, cordate at the base: styles more or less united, only toward the base, or nearly to the apex: capsule 1–1.8 cm. long.

Western Texas and northern Mexico to southern California and northern Lower California.

Specimens examined.—Texas: El Paso, *G. R. Vasey*, May, 1881, and *L. H. Dewey*, June 15, 1891; *Wright 228*, October, 1849. Mexico: Chihuahua and Sonora, *Thurber 401*, May, 1851; Coahuila, *Palmer 80*, 1880; San Pablo, *Gregg*, April 30, 1847. New Mexico: Grant Co., *Mearns 46*, 1892; Little Mt., near Las Cruces, *Wooton*, May and July, 1893. Arizona: Tucson, *Toumey*, April 20, 1894; Tucson Mts., *Toumey 465*, 1892; Willow Springs, *Jones*, May 29, 1890; Gila Valley, *Rothrock 319;* foothills, *Prin-*

gle, April 6, 1891; San Francisco Mts., *Wheeler*, 1872; Squaw Peak, *Mearns 173*, May 6, 1887; Ft. Huachuca, *Wilcox*, June 1, 1892, and *106*, 1894. California: *Emory*, November 29, 1846; *Frémont*, 1849; The Needles, *Jones 3831*, May 6, 1884; southern California, *Parish*. Lower California: Rosario, *Orcutt 1354*, May 1, 1886.

This species has a much more extended range than any of the others and is the only one found within the confines of the United States. It may be distinguished at once from narrow-panicled forms of *F. peninsularis* by the prominent appendage near the base of the filaments and by the larger capsule. It has a number of common names, among them being Ocotillo, Coach-whip, Vine-cactus, and Jacob's Staff.

6. **Fouquieria campanulata** sp. nov.

A woody plant with narrow panicle and red campanulate flowers. Leaves on the new growth 3–4 cm. long, petioled; petiole less than one half as long as the blade, which is 2–3 cm. long and 4–5 mm. wide, narrowly oblong or oblanceolate: fascicled leaves 2–3 cm. long, 3–6 mm. wide, oblanceolate, acutish, narrowed to the sessile base: inflorescence a narrow panicle 1.5 dm. long or less, the branches short and spreading and the flowers on them crowded: sepals broadly oval to orbicular, 5–6 cm. long, pale: corolla, from the tip of the recurved spreading lobes to the base of the tube, 12–14 mm. long, campanulate, the tube, which is about as long as the lobes, 3 mm. broad at the base, enlarging to the summit where it is 5–6 mm. in diameter: stamens exserted, unequal in length, the filaments broadened and compressed at the base, the broadened portion running out into a spreading or reflexed scale-like appendage which is pubescent on the upper surface and about 0.75 mm. long, the inner surface of the compressed portion glabrous, the outer surface pubescent with long hairs toward the summit, the remainder of the filament glabrous, anthers ovate-elliptic, cordate at the base, acute at the apex.

Durango.

Specimens examined.—Santiago Papasquiaro, *Palmer 87*, 1896.

An exception in the genus in having campanulate flowers. This and *F. splendens* are the only species which have well-developed appendages toward the base of the filaments.

2. IDRIA Kellogg, Hesperian, **4**: 101, *pl.* 1860

Trees with a stout columnar trunk from which arise short spreading spiny branches. Inflorescence paniculate, arising from the apex of the trunk, the flowers rather crowded and almost sessile upon the ultimate divisions of the panicle. Corolla yellow, campanulate, the lobes orbicular, concave, incurved, shorter than the tube. Stamens 10, adnate at the very base to the corolla-tube: filaments pubescent below. Styles short, thick, united their entire length, but little longer than the ovary, forming a stout 3-angled body, the angles rounded.

Species one; Lower California.

1. IDRIA COLUMNARIS Kellogg, Hesperian, **4**: 101. *pl.* 1860.

Fouquiera columnaris Kellogg; Curran, Bull. Cal. Acad. Sci. **1**: 133. *pl.* 1885.

Fouquiera gigantea Orcutt, West Am. Sci. **2**: 48. 1886.

A tall tree with a tapering trunk up to 3–4 m. in height or even taller, and a diameter at the base of about 3 dm. or more, from which arise the short spreading spiny and leafy branches. Leaves of the new growth unknown: fascicled leaves 1.5–2 cm. long and 5–8 mm. wide, oblanceolate to narrowly obovate: panicles 3 4 dm. long, flowers rather crowded and nearly sessile upon the ultimate divisions: flowers, including the exserted stamens, 12–14 mm. long: sepals orbicular, about 4 mm. long: corolla yellow, 6–7 mm. long: stamens exserted, the filaments pubescent below, the anthers about 3 mm. long: styles about 2 mm. long, thick.

Lower California.

Specimens examined. — Rosalia Bay, *Anthony 120*, July to October, 1896.

Originally collected by Dr. Veatch near the Bay of Sebastian Viscaino, on the mainland east of Cedros Island. The tree was described by Dr. Kellogg as spineless, but this must have been an error, as others who have visited the same region remark upon the long spines which are found on the short branches arising from the trunk. Moreover, a specimen in the herbarium of the New York Botanical Garden, collected by Anthony at Rosalia Bay, but a few miles north of the original station, shows these spine-bearing branches, the spines being similar to those occurring in the other members of this family. Dr. Kellogg describes the trunk as undivided, while Orcutt, in the description of his *Fouquiera gigantea*, states that the trunk branches above the middle, sending up a few simple branches to nearly the height of the main stem. Brandegee, in his account of a collection of plants made in Lower California in 1889 (Proc. Cal. Acad. Sci. II. **2**: 132, 133), also refers to this branched condition, but considers this state as exceptional and due to accident or injury. Both Brandegee and Orcutt claim the trunk attains a height of fifty feet or more. Brandegee remarks that the old capsules are 8–10 mm. long and sessile in the panicle, and that the trunks are 6–9 dm. in diameter at the base, gradually tapering upward into a pointed apex, so that the general shape is much like that of an inverted carrot.

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BULLETIN

OF THE

TORREY BOTANICAL CLUB

SEPTEMBER, 1903

Revision of the North American Species of Leskea

By G. N. Best

(With Plates 15 and 16)

The larger part of the material upon which this revision is based was furnished by the New York Botanical Garden, the Geological Survey of Canada, the Department of Agriculture at Washington, the Academy of Natural Sciences of Philadelphia and Harvard University. The author wishes to acknowledge his indebtedness to these institutions and to beg those having them in charge to accept his sincere thanks. He also wishes to acknowledge his obligations to Prof. John Macoun for the loan of duplicates and cotypes of Kindberg's new species; to Mrs. Britton for assistance in procuring types, in furnishing citations and rare specimens and for unnumbered kindnesses; to Prof. J. M. Holzinger for the contribution of a large number of valuable specimens from an unexplored region; to M. Jules Cardot for specimens, notes and publications; and to Dr. A. J. Grout, Dr. J. K. Small, Mr. R. S. Williams, Mr. C. F. Baker, Prof. F. S. Earle, Mr. H. N. Dixon, Mrs. A. M. Smith, Miss Edith A. Warner, Mr. E. D. Merrill, Mr. A. Gepp, Mr. John Moser and Dr. W. A. Kellerman for many and varied contributions. His thanks are especially due Miss Alexandrina Taylor for the excellent drawings which accompany this revision and on which its value so largely depends.

LESKEA Hedw. Fund. **2**: 93. 1782.

Plants small to medium-sized, growing in tufts about the base

[The preceding number of the BULLETIN, Vol. 30, No. 8, for August, 1903 (**30**: 423–462), was issued 4 Au 1903.]

of trees, on rotten wood, more rarely on stones, rocks or the ground, in damp shady places. Stems prostrate, usually radiculose, sometimes paraphyllose, pinnately to fasciculately branched, rarely stoloniferous ; central strand usually small, sometimes rudimentary or none ; leaves not heteromorphous, often papillose, ovate to ovate-lanceolate, acute, acuminate or obtuse, usually unicostate, sometimes shortly bicostate, nearly or quite entire (excl. *L. denticulata*) ; leaf-cells somewhat uniform, median quadrate-hexagonal to oval-oblong, rarely elongated : pedicels smooth : capsules usually straight and erect, sometimes curved, oval to subcylindric, annulate ; teeth well-developed, lanceolate-linear, divisural line and lamellae rarely absent ; endostomial band narrow, about one fourth to one sixth the length of the teeth ; segments linear, often keeled and cleft ; cilia usually none or rudimentary ; opercula mammillate to long conic, rarely rostellate ; calyptrae cucullate, smooth.

Leskea, written *Leskia* by Hedwig and so named in honor of Professor Gottfried Leske of Leipzig, formerly contained a large number of species which in more recent times have been divided up and placed under other genera. *Leskea paludosa* (1793), usually regarded as a variety of *L. polycarpa* Ehrh., *L. gracilescens* (1801) and *L. obscura* (1801) are the only Hedwigian species now recognized as belonging to this genus. As *Leskea* was founded in 1782, neither of these species could have been the first to have been described under it, and if the claim is allowed that the first species described under a genus is the type of that genus, it follows that the name *Leskea* or *Leskia* must displace that of some other genus and unless otherwise provided for, a new name must be given the one under consideration. The usually accepted type of *Leskea* is *L. polycarpa*, and since both the name and the type have had the sanction of all recent authorities the author of this revision feels constrained likewise to accept them even at the risk of having his citations subsequently overturned by some one less conservative than himself.

Key to the Species.

EULESKEA : leaves papillose, costate ; median cells usually isodiametric ; peristomial teeth abruptly incurved from a bulging base when dry.
- Leaves ovate-lanceolate, acute to acuminate, more than twice as long as wide.
  - Leaves more or less secund ; leaf-cells distinct.
    - Capsules straight ; operculum short-conic. *L. polycarpa.*
    - Capsules curved ; operculum long-conic. *L. arenicola.*
  - Leaves straight ; leaf-cells small, indistinct : capsules straight, erect. *L. microcarpa.*

Leaves ovate, subacute to obtuse, less than twice as long as wide.
Leaves symmetric, biplicate, margins often revolute. *L. gracilescens.*
Leaves asymmetric, not plicate, margins plane. *L. obscura.*
HETEROLESKEA: leaves smooth or nearly so, costate or ecostate, median cells longer than wide; peristomial teeth erect when dry.
Leaves denticulate, ecostate. *L. denticulata.*
Leaves entire or nearly so, costate;
Acumen longer than body;
Costa subpercurrent. *L. nervosa.*
Costa short. *L. Williamsi.*
Acumen shorter than body;
Costa short, bifid.
Leaves smooth. *L. tectorum.*
Leaves subpapillose. *L. cyrtophylla.*

1. LESKEA POLYCARPA Ehrh. Dec. Crypt. 96. 1788.

Hypnum repens trichodes arboreum medium capitulis erectis Dill. Cat. Giss. 216. 1718.

Hypnum trichodes, capsulis oblongis, in setis brevioribus Dill. Hist. Musc. 331. 1741.

Hypnum medium Dicks. Crypt. **2**: 12. 1790.

Hypnum polycarpon Hoffm. Deutsch. Fl. **2**: 67. 1796.

Leskea paludosa var. *polycarpa* Hartm. Skand. Fl. Ed. 5, 337. 1849.

In spreading tufts or loose mats, pale green, sometimes dirty dark green, passing to yellowish green or reddish brown; stems prostrate, 2–4 cm. long, radiculose, subpinnately branched; central strand small, distinct: paraphyllia few, linear-lanceolate: stem-leaves * loosely appressed when dry, erect-spreading when moist, 0.8–1.2 mm. long, 0.35–0.45 mm. wide, from a subcordate, slightly decurrent, ovate or oblong-ovate base, lanceolate, gradually acute to abruptly acuminate, more or less secund and obliquely pointed, biplicate, entire, one or both basal margins usually recurved, costa disappearing below apex; branch-leaves smaller, often obtuse or blunt-pointed; median cells of stem-leaves roundish quadrate-hexagonal, 7–8 μ wide, with one or two small papillae on each surface; basal quadrate-oblong; alar quadrate or transversely oval: monoicous: perichetial bracts erect, oblong-lanceolate, acuminate, inner subvaginant, plicate-striate, lightly costate; pedicel about 1 cm. long, smooth; capsule erect, straight or

---

* When stem-leaves are referred to those from the middle third of the stem are meant and when branch-leaves those from the middle third of a branch. In most species of this genus a considerable difference will be found between the upper and lower leaves. The plicae of the leaves are seen to the best advantage before pressure is applied.

slightly curved, subcylindric, tapering at base, greenish yellow changing to yellowish or reddish brown, wrinkled when dry and contracted below mouth; urn about 2 mm. long, 7 mm. wide; exothecial cells oblong-rectangular, thin-walled; teeth yellowish, linear-lanceolate, lamellate, dorsal line distinct; endostomial band about one fourth the length of the teeth; segments linear, nearly as long as teeth, scarcely open on the keel; cilia rudimentary or none; annulus of two rows of cells; operculum conic; calyptra cucullate; spores usually smooth, 9–12 μ, mature in early summer. On the base of trees, rotten wood, rarely on stones or the ground.

TYPE LOCALITY: Germany.

DISTRIBUTION: From Newfoundland westward through Canada to Montana and southward.

ILLUSTRATIONS: Husnot, Musc. Gal. *pl. 85.* Dixon & Jameson, Handbook, *pl. 50.* Braithwaite, Brit. Moss-Flora, **3**: *pl. 86.* Limpricht, Die Laubmoose, *f. 343.*

The typical European form of *L. polycarpa* is not so common in North America as is generally supposed, and when it does occur it is usually somewhat smaller. Between it and *L. obscura* a number of transitional forms are met with which differ from the former in having their leaves smaller, straighter and more obtuse. In fact these forms show the results of an influence which culminates in the production of *L. obscura*, a species unknown in Europe. As these intermediate forms are much more common than those of the types, it has been thought advantageous to cover them, at least in part, by admitting Hedwig's *L. gracilescens* which, if it has no other merit, has that of convenience.

2. **Leskea polycarpa subobtusifolia** (C. M. & K.).

Leskea subobtusifolia C. M. & K.; Macoun, Cat. Can. Pl. 6: 169. 1892.

Subsp. *L. obtusifolia* Kindb. Eur. & N. Am. Bry. 25. 1896.

Tufts dirty yellowish green; stems and branches curved at tips: stem-leaves subsecund, biplicate, ovate-oblong to ovate-lanceolate, subacute to obtuse, obliquely pointed, the lower acuminate and blunt-pointed, 1 mm. long, 0.4 mm. wide; leaf-cells as in *L. polycarpa.* Macoun, Canadian Musci 533.

Professor Macoun has kindly loaned me the duplicate of the type, collected at Sproat, Pass River, B. C., as well as other material from the same locality and referred to it. All the specimens are destitute of fruit and are unquestionably but forms of *L. polycarpa*, nearer however the var. *paludosa* than the type. It is retained as a variety from the fact that the sporophyte when found might possibly offer something distinctive entitling it to specific rank.

3. LESKEA POLYCARPA PALUDOSA (Hedw.) Schimp. Syn. 486. 1860.

? *Hypnum palustre* Huds. Fl. Angl. 429. 1762.
Leskea palustris Hedw. Descr. **4**: 1. *pl. 1.* 1793.
Leskea paludosa Hedw. Descr. **4**: 115. 1797.
Hypnum inundatum Dicks. Crypt. **4**: 17. 1801.

In dirty green, often blackish spreading tufts; stouter, more diffusely branched; stems and branches longer, somewhat curved at tips: stem-leaves usually secund, distant, ovate-lanceolate, acute to obtuse, sometimes obliquely acuminate, up to 1.4 mm. long and 0.5 mm. wide; median leaf-cells roundish quadrate, unipapillate on both surfaces; basal oblong-rectangular: capsule longer, often slightly bent or curved, reddish-brown with age. In wet places, sometimes submerged, about the base of trees and on rotten wood, rarely on stones.

With the type, but less frequent; more common in the northwest. North Dakota (Holzinger); Montana (Holzinger, Williams); Idaho (Röll); Oregon (Röll); British Columbia (Macoun).

European bryologists differ not a little in their treatment of *L. polycarpa* and var. *paludosa*. The stouter forms of the former are often assigned to the latter, in fact distinguishing characters are wanting. It is evident that the extremes are so closely connected by intergrading forms that it is impossible to say just where *L. polycarpa* ends and var. *paludosa* begins.

4. **Leskea arenicola** sp. nov.

Plants somewhat rigid, in loosely spreading tufts, pale yellowish green passing to reddish brown; stems 2–5 cm. long, creeping, radiculose, pinnately branched; branches simple, ascending, sometimes curved; central strand small, distinct: paraphyllia multiform, mostly linear-lanceolate: stem-leaves rigid, secund, 0.4–0.5 mm. wide, 0.8–1 mm. long, ovate to ovate-lanceolate, obliquely acuminate, acute to blunt-pointed, scarcely biplicate, margins usually recurved at base, entire or sinuate-serrulate above, costa disappearing in the acumen; leaf-cells somewhat clear, stoutly unipapillate on under surface, usually smooth on upper alar; cells quadrate, in 5 or 6 rows; median oval-rhombic to oblong-fusiform, 7–9 μ wide, about twice as long; branch-leaves broadly lanceolate, scarcely secund, 0.25–0.35 mm. wide, 0.5–0.7 mm. long: monoicous: perichetial bracts appressed, plicate, costate, long and narrowly acuminate, entire or serrulate above; pedicel 1.5 cm. long, grooved, twisted to the left below, to the right above, curved, reddish; capsule oblong-cylindric, curved, tapering at base, wrinkled when dry; urn about 2 mm. long, 0.6 mm. wide; exothecial cells oblong-linear, thick-walled; annulus broad, 2–3 rows of cells; teeth lanceolate-linear, 0.6–0.7 mm. long, 0.03 mm. wide, yellowish below, pale above, densely papillose, divisural line faint, ventral surface strongly lamellate; endostomial band yellowish, papillose, about one seventh the length of the teeth; segments as long as teeth, split, scarcely open on the keel; cilia rudimentary; operculum whitish, subshining, narrowly conic, about one half as long as the urn; calyptra cucullate; spores smooth, 10–13 μ, mature in early summer. On the base of trees, rarely on decaying wood, in sandy places. (PLATE 15, FIGS. 1–13.)

TYPE LOCALITY: Delaware; collected by Mr. A. Commons, June 9, 1894; type in the New York Botanical Garden.

DISTRIBUTION: From Maine southward along the coast to Virginia and northward and westward to Minnesota and Dakota. Maine (Merrill); New York (Maxon, Grout); New Jersey (Best); Delaware (Commons); Maryland (Smith, Holzinger); Virginia (Vail and Britton); Ohio (Lesquereux); North Dakota (Holzinger); Minnesota (Holzinger).

EXSICCATAE: S. & L. Musc. Bor. Am. *243* and *365* as *L. obscura;* Ren. & Card. Musc. Am. Sept. *192*^{b} as *L. polycarpa forma.*

My first acquaintance with *L. arenicola* was in *1892* while collecting in the New Jersey pine-barrens. Recognizing its distinctness as a species specimens of it were distributed under this name. Subsequently, however, while examining the collection of the New York Botanical Garden, the same species was found under the name of *L. Donnellii*, having been collected in Maryland by Mr. J. Donnell Smith and so named by Austin. The type being in a poor condition, with only fragments of peristomes and no opercula, it was thought best to discard Austin's manuscript name and use a new type as well as a new name.

L. arenicola is readily distinguished from all other species of *Euleskea* by its curved capsules, longer teeth and segments, longer and narrower opercula and by its rhombic, elongated leaf-cells. In its general appearance it resembles some forms of *L. polycarpa paludosa*, from which it is however easily separated by the characters just named. When once understood it will probably be found more common than here indicated.

5. LESKEA GRACILESCENS Hedw. Spec. Musc. 222. *pl. 56, f. 8–13.* 1801.

Leskea intermedia olim mihi.

In intricate spreading tufts, pale to dark green passing to reddish-brown or blackish ; stems 2–4 cm. long, creeping, radiculose, pinnately branched ; central strand rudimentary or none ; branches simple, erect, often subjulaceous : paraphyllia few, lanceolate, rarely none : stem-leaves appressed-imbricated when dry, erect-spreading when moist, 0.4–0.5 mm. wide, 0.65–0.9 mm. long, ovate, gradually acute, obtuse or blunt-pointed, straight, lightly biplicate, margins entire, often more or less revolute, costa subpercurrent ; branch-leaves similar, not plicate ; leaf-cells somewhat uniform, unipapillate on lower surface, usually smooth on upper ; median quadrate-hexagonal, 8–10 μ broad ; alar and basal quadrate ; apical roundish : monoicous : perichetial bracts erect, striate, blunt, inner subvaginant, costate ; pedicel 8–10 mm. long ; capsule erect, oblong-cylindric, tapering at base, substriate and reddish when empty ; urn 1.5–2 mm. long, 0.6 mm. wide ; exothecial cells oblong, a few rows of roundish cells about the mouth ; annulus of two rows of cells, deciduous ; teeth whitish, lanceolate-linear, divisural line faint, lamellate, 0.35–0.45 mm. long ; endostomial band about one quarter the length of the teeth ; segments linear, usually shorter than the teeth, carinate, open, sometimes poorly developed and unequal ; cilia none ; operculum conic, obtuse or acute ; calyptra smooth, cucullate ; spores smooth, 8–11 μ, mature in early summer. On the base of trees, rotten wood, stones and the ground.

TYPE LOCALITY : Pennsylvania ; duplicate of type in the Academy of Natural Sciences of Philadelphia.*

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* M. Cardot, who has made a careful study of Hedwig's types of American Mosses as found in Herb. Boissier, informs me that *L. gracilescens* is not among them. In the Muhlenberg collection, now in possession of the Academy of Natural Sciences of Philadelphia, there are, however, a number of specimens so named, either positively or questionably. It is probable that one of these is a duplicate of the type, but which one can only be conjectured, since there are no indications pointing to this fact. These specimens, as also those of *L. obscura* in the same collection, make it evident that Hedwig, after founding these species, failed to recognize their distinguishing characters, as nearly all of Muhlenberg's later collections are named either "*L. gracilescens ?*" or

L. gracilescens is quite common and widely distributed, ranging through the Eastern, Middle, Northern and Western States, rare in Canada and in the Southern States and absent west of the Rocky Mountains. It differs from the closely related *L. polycarpa* by its smaller straight leaves which are shorter and comparatively broader, usually gradually acute and blunt-pointed, and by its shorter, often unequal segments. In some of its forms it approaches *L. polycarpa*, in others *L. obscura*, without however fitting either as a variety. In general terms it may be said that all those doubtful forms that plainly do not belong to either of these species should be referred to *L. gracilescens*, which moreover has priority over the last.

6. LESKEA OBSCURA Hedw. Spec. Musc. 223. *pl. 57. f. 1–9.* 1801.

Leskea obtusa Ren. & Card. Bot. Gaz. **17**: 296. 1892.

Leskea? Cardoti Kindb. Rev. Bryol. **22**: 83. 1895.

In loose, spreading tufts, rarely in mats, deep green to dark olive green, older parts rusty brown; stems prostrate, 3–5 cm. long, radiculose, sparingly branched; central strand small, distinct: paraphyllia few, lanceolate, or none: branches short, tumid, or elongated and slender: stem-leaves incurved-appressed when dry, patulous when moist, oblong-ovate, 0.4–0.6 mm. wide, 0.8–1.3 mm. long, straight or slightly curved, thickish, concave, subcarinate, asymmetric, margins plane, apex rounded-obtuse or subacute, entire or serrulate, costa disappearing below apex; branch-leaves similar, more symmetric, obtuse, acute or short acuminate; leaf-cells somewhat uniform, pluripapillate on lower surface with small papillae, papillose or nearly smooth on upper; median cells quadrate-hexagonal, 8–10 μ wide; basal quadrate-oblong; apical smaller and roundish: monoicous: perichetial bracts erect, appressed, inner subvaginant, costate, blunt-pointed; pedicel smooth, reddish, 1–1.5 cm. long; capsule erect, straight, oblong-cylindric, thin-walled, yellowish, wrinkled and slightly contracted below mouth when dry; urn 1.75–2.25 mm. long, 0.8 mm. wide; exothecial cells oblong-rectangular; teeth linear-lanceolate, yellowish, papillose, lamellate, divisural line distinct below, faint above; endostomial band yellowish, about one fifth the length of the teeth; segments linear, densely papillose, more

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"*L. obscura?*" In this connection it is worthy of note that Hedwig did not regard any of the Muhlenberg mosses as *L. polycarpa*, with which, it is to be presumed, he was familiar.

or less open, shorter than the teeth; annulus of two rows of cells; operculum short-conic, obtuse or apiculate; spores smooth, 11–14 μ, mature in early summer. On the base of trees or rotten wood; more rarely on stones or the ground in wet places. (PLATE 15, FIGS. 14–27.)

TYPE LOCALITY: Pennsylvania; type in Herb. Boissier.

EXSICCATAE: Drumm. Musc. Amer. *105;* Austin, Musc. Appalach. *270;* Ren. & Card. Musc. Am. Sept. *193.*

ILLUSTRATIONS: Cardot, Bull. Herb. Boissier, **7**: *pl. 9. f. 4.* Sulliv. Icon. Musc. *pl. 77* is probably a form of *L. gracilescens*, as the margins of the stem-leaves are recurved. Dr. Robinson is unable to find the specimen in the Sullivant collection from which these drawings were made.

L. obscura has about the same range as the preceding, except that it is more frequent southward. Not rarely it grows mixed with *Anomodon attenuatus* and *A. obtusifolius*, to both of which it bears a superficial resemblance. In drying the leaves commonly take on an ashen or plumbeous tint and the lower surface a finely granular appearance. In its typical form *L. obscura* differs from *L. polycarpa* and *L. gracilescens* by its thicker, asymmetric, rounded-obtuse leaves, not plicate and with plane margins; the segments moreover are stouter, more densely papillose and usually more open. Some difficulty may be experienced in discriminating between this species and certain forms of *L. polycarpa paludosa.* The leaves, however, of the latter are usually longer, more or less secund and acuminate, obliquely and sometimes obtusely pointed, the leaf-cells unipapillate and the reddish-brown capsule longer, as also the segments. The most valuable character in differentiating *L. obscura* from the preceding species is the thicker texture of the leaves, the cells of which are covered with minute papillae, resembling those of *Anomodon attenuatus*, but not so many, nor so distinct.*

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* We are indebted to M. Cardot for having first called our attention to the distinguishing characters, at least in part, of *L. obscura.* In his valuable "Revision des types d'Hedwig et de Schwaegrichen" (Bull. Herb. Boissier, **7**: 348) we are told that there are two series of specimens on the sheet of the type of this species, named respectively "*a. arborea*" and "*b. terrestris*"; that the latter is the one to which Hedwig's description applies and that the former is *L. polycarpa.* On *pl. 9, f. 4* of this "Revision" (l. c.) are drawings of two leaves taken from the "*arborea*" series. As far as it is possible to determine, these are identical with the leaves of *L. gracilescens*

7. LESKEA MICROCARPA W. P. Schimper, in Sulliv. Musci and Hepaticae of the U. S. 59. 1856.

Plants smallest of the genus, in thin spreading tufts, yellowish green to dark green; stems 1–3 cm. long, creeping, radiculose, subpinnately branched; central strand minute or none: paraphyllia few, small, lanceolate: stem-leaves somewhat rigid, appressed when dry, spreading when moist, 0.3–0.4 mm. wide, 0.4–0.55 mm. long, ovate, subcordate, more or less narrowly long-acuminate, entire, basal margins revolute, costa subpercurrent, rough below; branch-leaves erect-spreading, acute to narrowly acuminate, 0.2–0.25 mm. wide, 0.3–0.35 mm. long, sometimes smaller; leaf-cells small, angular, papillose on lower surface, usually smooth on upper; median cells quadrate-hexagonal, irregular, often indistinct, 5–7 μ wide: alar oval-quadrate in about 6 rows: monoicous: perichetial bracts somewhat loose, erect or spreading at tips, long and narrowly acuminate, costate; pedicel smooth, erect, 5–7 mm. high; capsule erect, oval-oblong, reddish-brown, shining; urn about 1.5 mm. long and 0.6 mm. wide; exothecial cells large, irregular, rather thick-walled, roundish ovate-oblong, about 4 rows of smaller, oval, reddish cells about the mouth; teeth fragile, whitish, papillose, linear-lanceolate, 0.25 mm. long, confluent at the somewhat broadened base, not markedly bulging when dry, dorsal line faint or none; endostomial band thin, whitish, about 0.07 mm. broad; segments short, often rudimentary; annulus narrow, one to two rows of cells; operculum conic, short-beaked; spores slightly roughened, 9–13 μ wide, mature in spring. On roots of trees, rotten wood, rarely on the ground. (PLATE 15, FIGS. 28–40.)

TYPE LOCALITY: probably Alabama.

DISTRIBUTION: Florida (Langlois, Rapp); Alabama (Mohr, Earle & Baker); Louisiana (Langlois); Texas (Boll, Thomson, Wright). A specimen in the Gray Herbarium, Harvard University, from Natchez, but without name of collector.

EXSICCATAE: Drumm. Musc. Amer. (S. States) *89* as *L. nervosa;* Sullivant, Musc. Allegh. *67* as *L. polycarpa;* Sullivant, Musc. Allegh. *69* as *L. nervosa;* Ren. & Card. Musc. Amer. Sept. *194* as *L. gracilescens;* Langlois, Fl. Ludov. *246*.

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as found in the Muhlenberg collection. It would therefore appear quite probable that the moss to which Hedwig gave this name is the same that M. Cardot has referred to *L. polycarpa*. But Renauld & Cardot in their Musci Americae Septentrionalis Exsiccati *no. 194*, for reasons best known to themselves, have applied this name to a moss that belongs exclusively to the southern states, *L. microcarpa* Sch., which in all probability Hedwig never saw and which is quite different from his *L. gracilescens*.

The characters of *L. microcarpa* are fairly constant, except the acumination of the leaves, which varies considerably. In Musc. Allegh. *no. 69*, taken as the type, the leaves are rather long and narrowly acuminate, in this respect resembling *L. nervosa*; but in the ordinary forms of the species they are shorter acuminate, not rarely gradually acute, sometimes even blunt-pointed or obtuse. *L. microcarpa* differs from *L. nervosa* in being monoicous, leaves papillose, costa rough on lower surface and exothecial cells roundish oblong. Its distinguishing characters are its small angular leaf-cells and its rough costa.

8. LESKEA NERVOSA (Schwägr.) Myrin, Coroll. Fl. Upsal. 52. 1834. Bry. Eur. fasc. 44 and 45 Mon. 4. *pl. 3*. 1850.

Pterogonium nervosum Schwägr. Suppl. 1^1: 102. 1811.

Anomodon rigidulus Kindb. Laubm. Schwed. u. Norw. 11. 1883.

Anomodon subrigidulus Kindb. Eur. and N. Am. Bry. 11. 1896.*

In thin appressed tufts, pale green to dark green, older parts rusty brown or black; stems creeping, 4–7 cm. long, radiculose, not paraphyllose, pinnately branched; branches simple, ascending, sometimes branched; central strand small, distinct: stem-leaves broadly ovate, subcordate, slightly decurrent, abruptly long-acuminate, 0.35–0.5 mm. wide, 0.8–1.3 mm. long; acumen narrowly lanceolate-linear, more or less recurved, margins plane, subsinuate; body concave (subcochleariform), biplicate, margins sometimes recurved on one or both sides; costa subpercurrent, narrow, scarcely tapering; branch-leaves narrow, rigid, erect-spreading, 0.2–0.3 mm. wide, 0.6–0.9 mm. long; leaf-cells smooth or scarcely papillose, somewhat uniform; median cells oval-hexagonal to oval-oblong, $7–9\mu \times 8–12\mu$; alar quadrate to transversely oval in 5 or 6 rows, extending well up the margins and becoming roundish: dioicous: perichetial bracts long and narrowly acuminate, inner erect, subvaginant, slightly costate; pedicel smooth, 10–12 mm. long; capsule erect, subcylindric, brownish, wrinkled when dry; urn 2.2 mm. long, 0.7 mm. wide; exothecial cells oblong, several rows about mouth roundish hexagonal, thick-walled; teeth erect, confluent at base, linear-lanceolate, yellowish, margined, dorsal surface finely striate, divisural

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* For a more extended synonymy of this species as well as the others of this Revision the reader is referrred to Limpricht's "Die Laubmoose" and Braithwaite's "British Moss-Flora."

line zigzag, ventral surface lamellate; endostomial band adherent to the columella, narrow, about one fourth the length of the teeth; segments irregular, unequal, sometimes rudimentary; annulus of two rows of cells, deciduous in pieces; operculum conic, obliquely short-beaked; calyptra cucullate, reaching the base of capsule; spores roughened, 12–15 μ, mature in summer. About the base of trees, rarely on rotten wood or stones. (PLATE 16, FIGS. 41–54.)

TYPE LOCALITY: Germany.

DISTRIBUTION: From Labrador to British Columbia, southward to Pennsylvania (Burnett) and Colorado (Holzinger). Usually sterile in the United States; fruiting in Smuggler's Notch, Vermont (Mrs. Britton); frequently fertile in British America (Macoun).

EXSICCATAE: Austin, Musc. Appalach. *271*; Macoun, Canad. Musc. *252*.

As with all widely distributed species, *L. nervosa* is somewhat variable. Depauperate growths with flagelliform branchlets and rudimentary leaves are common. Small heads or spikes of bulbils (gemmae), usually borne on the distal ends of stems and branches, are present in most specimens whether fruiting or not. *L. bulbifera* Brid. is a sterile form with bulbils. In the absence of other distinguishing characters, Bridel's species seems scarcely worthy of varietal rank, much less specific. Brownish septate brood-bodies (propagula) are occasionally found on the leaves of this species.

9. **Leskea nervosa nigrescens** (Kindb.).

Leskea nigrescens Kindb. Bull. Torrey Club, **16**: 97. 1889.

Leskea nervosa var. *flagellifera* Kindb. Ottawa Nat. **4**: 62. 1890.

Anomodon heteroideus Kindb.; Macoun, Cat. Can. P. 6: 62. 1890; Eur. & N. Am. Bry. 12. 1896.

In intricate tufts or mats, dirty yellowish green to dark green or black; stems 2–3 cm. long, creeping, scarcely radiculose, defoliate or with distant ovate narrowly acuminate recurved leaves, irregularly branched; branches usually few, short, ascending with numerous flagelliform branchlets, commonly bearing bulbils at their tips: branch-leaves as in type but smaller, 0.2–0.3 mm. wide, 0.4–0.6 mm. long; leaf-cells quadrate-hexagonal, smooth or slightly papillose, 6–8 μ wide; leaves of branchlets rudimentary, scarcely costate: sterile. On the base of trees, sometimes on stones and rocks; with the type but less common; Canad. Musc. *395*.

In nearly all specimens of this variety leaves from either stems or branches may be found sufficiently developed to show that they are identical with those of *L. nervosa*, proving conclusively that var. *nigrescens* is only a retrograde form of this species. Moreover tufts are often made up of both plants growing together, the one bearing bulbils in small heads, the other a few on flagellate branchlets. While these organs are usually sessile when in compact clusters, they sometimes appear on short flagellate stems, thus constituting a transitional form between those of the type and those of var. *nigrescens*. Such was conspicuously the case with a specimen from Vermont (Dr. Grout).

10. LESKEA DENTICULATA Sullivant, Musci Alleghen. No. 62. 1845; Mosses of the U. S. 59. 1856.

Hypnum fabroniaefolium C. Müll. Syn. **2**: 271. 1851.

Plants small, in depressed tufts, pale green, soft, somewhat silky; stems prostrate, 2–4 cm. long, sparingly radiculose, irregularly branched, without central strand or paraphyllia; stems and branches flattened when moist, sometimes subjulaceous when dry: stem-leaves close, erect-spreading, concave, subdecurrent, ovate, somewhat abruptly and narrowly acuminate, 0.5–0.7 mm. long, 0.3–0.4 mm. wide, ecostate, rarely with diverging striae; margins plane, minutely papillose-denticulate; branch-leaves smaller, more gradually acuminate, 0.3–0.4 mm. long, 0.2–0.3 mm. wide; leaf-cells somewhat uniform, primordial utricle usually distinct, unipapillate on lower surface; median cells oval-oblong to sublinear-rhomboidal, 6–8 μ wide, two to four times as long, rarely longer and subvermicular; alar quadrate, thick-walled, passing abruptly to the median; marginal curvilinear, in a single row; cells of branch-leaves shorter, oval-rhombic to oblong: dioicous: pedicel smooth, 4–8 mm. long; capsule oval-oblong, suberect; teeth linear-lanceolate, long-pointed; endostomial band?; segments nearly as long and as broad as teeth, carinate, cleft between the joints; cilia none; annulus none; operculum rostellate from a broad highly convex or conical base; calyptra cucullate; spores?, mature? On base of trees, rarely on rocks; seldom fruiting; sometimes flagelliferous.

TYPE LOCALITY: Balsam Mt., N. C.; type in the Gray Herbarium, Harvard University.

DISTRIBUTION: From New York (Austin) westward to Indiana (Haines) and southward to Florida (J. D. Smith); New Jersey (Austin); Pennsylvania (Burnett); Ohio (Biddlecome);

Virginia (Vail and Britton); North Carolina (Sullivant); Georgia (Harper); Alabama (Mohr); Louisiana (Langlois).

Exsiccatae: Drumm. Musc. Am. (S. States) *86* as *Pterogonium filiforme*, var.?; Austin, Musc. Appalach. *267;* S. & L. Musc. Bor.-Amer., ed. 1, *245;* ed. 2, *347;* Ren. & Card., Musc. Amer. Sept. *85*.

Illustration: Sulliv. Icon. Musc. *pl. 78*.

As good fruiting material of *L. denticulata* was not at hand, the somewhat imperfect description of the sporophyte was taken from Sullivant's Icones Muscorum. The generic position of this species is open to question, as indicated by Sullivant in Mosses of the United States. The leaves in shape and areolation resemble those of the *Fabroniae*. The papillae on their dorsal surfaces appear to have escaped Sullivant's notice. It is quite probable that when better understood *L. denticulata* will be assigned to some other genus.

11. **Leskea Williamsi** sp. nov.

Plants quite small, in spreading subshining tufts, pale yellow to golden brown; stems slender, creeping, radiculose, pinnately branched, 2–4 cm. long; central strand none; branches ascending, simple or with flagellate branchlets: lower stem-leaves decolorate, roundish ovate, abruptly acuminate, costa short, nearly obsolete; upper stem-leaves appressed when dry, erect-spreading when moist, straight or subsecund, entire or serrulate above, ovate-lanceolate, acuminate, acumen about as long as the concave biplicate body, 0.25–0.35 mm. wide, 0.4–0.5 mm. long; margins recurved below or plane all around; costa short, thin, simple or bifid, scarcely reaching the middle; branch-leaves smaller, 0.15–0.20 mm. wide, 0.25–0.4 mm. long; leaf-cells smooth, clear; median linear-rhomboidal to fusiform, subvermicular, about 6 μ wide, 3–5 times as long; alar quadrate to transversely oval, in about 4 rows, extending well up the margins and passing to oval-oblong: dioicous: perichetial bracts oblong-lanceolate, acuminate, striate-plicate, inner subvaginant; pedicel smooth, flexuous, about 1 cm. long; capsule straight, erect or inclined, oblong-subcylindric, tapering at base; urn 2 mm. long, 0.7 mm. wide, brownish; teeth reddish, incurved when dry, lanceolate, confluent at base, finely striate below, rugulose above, divisural line distinct, ventral surface lamellose; endostomial band strongly reticulated, about one fourth the length of the teeth; segments narrow, concave-keeled, hiant, about as long as teeth; cilia none; annulus of two rows of pellucid cells, shed with the operculum; operculum conic, straight or obliquely beaked; calyptra cucullate, reaching to the base of the capsule; spores smooth, 10–13 μ wide, mature in summer. On rocks and rotten wood. (PLATE 16, FIGS. 55–68.)

TYPE LOCALITY: Montana; type collected by Mr. R. S. Williams, on Tenderfoot or Belt Mountains, Sept. 9, 1891; now in the Herbarium of the New York Botanical Garden; also collected by Mr. Williams at Columbia Falls, Mont., and by Prof. Holzinger in Minnesota.

In general appearance *L. Williamsi* resembles the smaller forms of *L. tectorum*, from which it differs, however, by its narrower, longer acuminate, often serrate leaves, its longer median cells, its broader, strongly reticulated endostome and its striate-plicate perichetial bracts. Named in honor of my friend Mr. R. S. Williams.

12. **Leskea Williamsi filamentosa** var. nov.

In thin loosely spreading or somewhat intricate tufts, pale green passing to yellowish green or reddish brown; stems prostrate, defoliate or with a few rudimentary leaves, sparingly branched; branches filiform, diffusely spreading, 2–5 cm. long; branchlets flagellate, brittle, broken when dry: larger branch-leaves narrowly ovate-lanceolate, long-acuminate, erect, not plicate, entire or serrulate above, 0.15–0.2 mm. wide, 0.3–0.5 mm. long; costa thin, commonly marked by 3 or 4 rows of enlarged cells, disappearing below the middle; leaf-cells smooth, clear, not uniform; median cells oval-rhombic to linear-rhomboidal, 2–4 times as long as wide; alar quadrate, in 3 or 4 rows; leaves of branchlets similar, smaller, sometimes rudimentary: sterile.

Type of variety collected by Mr. L. F. Anderson on rocks near Lahoon, Idaho. Drummond's Musci Americana *219*, in part; Brandegee's Mosses of Southern Colorado *38*.

This delicate little moss appears to have been a standing puzzle for several years. It was found in some of the sets of Drummond's Musci Americana *no. 219*, but not in all, and was distributed as *Hypnum catenulatum*. Some of the other sets of this number, but not all, contained *Heterocladium heteropterioides filescens*, a moss it closely resembles, but which differs in being papillose. Some years ago Mr. Gepp sent me from the Natural History Museum in London a portion of one set of Drummond's *219* bearing the name of *Hypnum graveolens* Wils. It therefore appears that so good an authority as Wilson had discovered that the moss in question was not *Leskea catenulata* (Brid.). Subsequently Mrs. Britton gave me some specimens of Brandegee's *no. 38* which I named *Heterocladium heteropterum fallax* Milde ?. A careful study of Drummond's *219* and Brandegee's *38* made it obvious that we had to deal with an attenuated form of some species which under more favorable conditions grew better developed.

13. LESKEA TECTORUM (A. Braun) Lindb. Bot. Notis. **1865**: 73. 1865.

Pterogonium tectorum A. Braun; Brid. Bryol. Univ. **2**: 582. 1827.

Leskea Wollei Austin, Bull. Torrey Club, **5**: 28. 1874.

Pseudoleskea malacoclada C. M. & K.; Macoun, Cat. Can. Pl. 6. 182. 1892.

Plants small, in rather dense subshining tufts or mats, deep green passing to reddish brown or black; stems prostrate, 2–5 cm. long, radiculose, pinnately branched; branches ascending, short, simple, sometimes with flagellate branchlets, sharply pointed when dry; central strand small, distinct: paraphyllia few, lanceolate, sometimes none: lower stem-leaves broadly ovate, abruptly and narrowly acuminate, acumen spreading or recurved; upper stem-leaves subdecurrent, ovate, abruptly acuminate, acumen shorter than the concave scarcely plicate body; margins entire, plane or recurved on one or both sides below; branch-leaves ovate, abruptly or gradually acuminate, margins plane, entire, costa short, simple, sometimes forking, rarely none; leaf-cells somewhat uniform, smooth, clear, thin-walled; median cells oval-oblong to oblong-rhomboidal, rounded at both ends, 9–12 μ wide, 1½–3 times as long; alar transversely compressed in 5–7 rows; upper rhombic-oval or roundish: dioicous: [perichetial bracts erect, long-acuminate, the inner shorter, blunt-pointed and coarsely serrate at point: pedicel purple, 1.5 cm. long, curved at base; capsule cylindric, somewhat curved, reddish brown; urn 2.7 mm. long, 0.75 mm. wide; exothecial cells rectangular, somewhat elongated; annulus of two rows of cubical cells, separating from the operculum; teeth lanceolate, yellowish, thinly margined, divisural line straight, inner surface lamellose; endostomial band yellowish, one sixth the length of the teeth; segments about as long as the teeth, narrow, constricted at the joints, keeled, not hiant; cilia none or rudimentary; spores 10–14 μ, brownish, smooth, maturing in August.]* (PLATE 16, FIGS. 69–76.)

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* Abstracted from Limpricht's Die Laubmoose, **2**: 271; described from fruiting specimens collected by E. Ryan in Norway, the only fruiting locality known.

On rocks, rotton wood and bases of trees. (In Europe commonly found on roofs, slate, tile or wood.)

TYPE LOCALITY: Germany.

DISTRIBUTION: From Lake Superior (Wolle, Macoun) westward to British Columbia (Macoun) and northward to the Yukon (Williams); Colorado (Blake & Holzinger); Minnesota (Holzinger).

ILLUSTRATION: Husnot, Musc. Gal. *pl. 86.*

Widely distributed and quite variable, *L. tectorum* is usually easily recognized when once understood. Its leaf-cells, broad, plump, rounded, glassy, furnish its most distinctive character. Its leaves are quite like those of *Amblystegium adnatum* but somewhat smaller. This differs, however, in having its leaf-cells longer and narrower, especially in the upper part of the leaves, so that no difficulty need be experienced in discriminating between the two species. The closely allied European *Leskea catenulata* (Schwägr.) Brid., undoubted specimens of which have not as yet been reported from North America, may be known by its narrower, longer and thicker costa, usually reaching the middle and not forking, and by its thick-walled leaf-cells.

The type of *L. Wollei* Aust. has been compared with European specimens of *L. tectorum*, with the result of finding them nearly or quite identical. While the median leaf-cells are slightly longer, sometimes more rhomboidal than in the ordinary forms of this species, the same variations occur in foreign specimens. The cotype of *Pseudoleskea malacoclada* C. M. & K., through the kindnese of Prof. Macoun, has likewise been seen and carefully examined. Although it is slightly stouter and the basal margins of the leaves are more commonly recurved, it differs in none of the essentials from the specific type of *L. tectorum*.

14. **Leskea tectorum flagellifera** var. nov.

In somewhat dense compact tufts, pale green to yellowish-brown; stems prostrate, pinnately branched; branches filiform with numerous flagellate deciduous branchlets; stems defoliate, rarely with rudimentary leaves; branch-leaves as in type but usually much smaller; leaf-cells smooth, clear, oval-rhombic; leaves of branchlets very small, 0.05–0.1 mm. wide, 0.1–0.2 mm. long. Differs from *L. Williamsi filamentosa* by its entire leaves and larger leaf-cells. Type of variety collected by Mr. R. S. Williams at Columbia Falls, Montana, Sept. 5, 1895; found also by Professor Holzinger in Minnesota. It usually grows on rocks and rotten wood.

The North American *Heteroleskeae* differ from the European by being usually more markedly proliferous. The somewhat dense tufts of var. *flagellifera* are mostly flagellate branchlets which when dry readily separate from their attachments. By soaking these tufts and dissecting out the stems and branches leaves may usually be found sufficiently developed to make possible the identification of the plants.

15. LESKEA CYRTOPHYLLA Kindb. in Macoun, Cat. Can. Pl. 6: 169. 1892.

Plants very small, in rather compact tufts, deep green to rusty brown; stems 1–2 cm. long, prostrate, scarcely radiculose, irregularly branched; branches erect, simple or with flagellate branchlets: paraphyllia usually none: stem-leaves somewhat spreading, roundish ovate, concave, broadly inserted, 0.3–0.4 mm. wide, 0.4–0.5 mm. long, abruptly acuminate, acumen usually sharp-pointed; costa short, thin, usually forking; margins entire, sometimes recurved below; branch-leaves roundish-ovate, rather gradually acute or short-acuminate, often blunt-pointed, 0.2–0.25 mm. wide, 0.25–0.3 mm. long; leaf-cells rounded or angular, not uniform, somewhat clear, with usually a small flat subcentral papilla on each surface; median cells oval-rhombic, 9–13 μ wide, 12–16 μ long; alar transversely compressed, in 5–7 rows: apparently dioicous: capsules not seen. On rocks and stones.

TYPE LOCALITY: Canada; type collected by Prof. John Macoun, July 10, 1884, on rocks on islands in Lake Nepigon; now in the museum of the Geological Survey of Canada.

Leskea cyrtophylla is closely related to *L. tectorum*, differing from this species more especially by being somewhat papillose. It may be regarded as a transitional form connecting *L. tectorum* with *Heterocladium papillosum* Lindb. (An authentic specimen of the latter has been seen through the kindness of Professor Holzinger and Mr. Harald Lindberg.) The type of *L. cyrtophylla* is flagellate and depauperate. Much better material of apparently the same has been collected in Colorado and Minnesota by Professor Holzinger.

ROSEMONT, N. J.

Explanation of Plates

PLATE 15

Leskea arenicola

1. Plant, natural size.
2, 3. Outlines of stem-leaves. × 44.
4, 5. Outlines of branch-leaves. × 44.
6. Apex of stem-leaf. × 170.
7. Median cells of leaf. × 390
8. Cross-section of stem. × 235.
9. Perichetial bud. × 7½.
10. Inner perichetial bract. × 18.
11. Capsule. × 9.
12. Peristome (annulus of three rows). × 100.
13. Spores. × 100.

Leskea obscura

14. Plant, natural size.
15, 16. Outlines of stem-leaves. × 44.
17. Outlines of branch-leaves. × 44.
18. Apex of stem-leaf. × 170.
19. Median cells from leaf. × 390.
20. Cross-section of stem. × 235.
21, 22. Perichetial buds. × 7½.
23. Inner perichetial bract. × 18.
24. Capsule. × 9.
25. Peristome (annulus for the most part of two rows). × 100.
26. Spores. × 100.
27. Longitudinal section through peristome. × 130.

Leskea microcarpa

28. Plant, natural size.
29. Outline of stem-leaf. × 44.
30, 31, 32. Outlines of branch-leaves. × 44.
33. Apex of stem-leaf. × 170.
34. Median cells of leaf. × 390.
35. Cross-section of stem. × 235.
36. Perichetial bud. × 7½.
37. Inner perichetial bract. × 18.
38. Capsule. × 9.
39. Peristome (annulus for the most part of one row). × 100.
40. Spores. × 100.

PLATE 16

Leskea nervosa

41. Plant, natural size.
42, 43. Outlines of stem-leaves. × 44.
44, 45. Outlines of branch-leaves. × 44.

46. Apex of stem-leaf. × 130.
47. Median cells of leaf. × 310.
48. Cross-section of leaf. × 130.
49. Cross-section of stem. × 130.
50. Perichetial bud. × 7½.
51. Perichetial leaf. × 20.
52. Capsule. × 15½.
53. Peristome. × 130.
54. Spores. × 130.

Leskea Williamsi

55. Plant, natural size.
56, 57. Outlines of stem-leaves. × 44.
58, 59, 60. Outlines of branch-leaves. × 44.
61. Apex of stem-leaf. × 130.
62. Median cells of leaf. × 310.
63. Cross-section of stem. × 130.
64. Perichetial bud. × 7½.
65. Perichetial leaf. × 20.
66. Capsule. × 15½.
67. Peristome. × 130.
68. Spores. × 130.

Leskea tectorum

69. Plant, natural size.
70. Outline of a portion of stem. × 20.
71. Outline of stem-leaf. × 44.
72. Outline of branch-leaf. × 44.
73. Apex of stem-leaf. × 130.
74. Median cells of leaf. × 310.
75. Cross-section of leaf. × 130.
76. Cross-section of stem. × 130.

New Species of Western Plants

By Alice Eastwood

Zygadenus micranthus

Bulb globose, clothed with brownish black outer coats, about 1.5 cm. in diameter: stems slender, erect, 1–5 dm. high, scabrous, somewhat leafy: leaves falcate, the lowest more than half the height of the plant, striate, scabrous, the edges folded together, varying greatly in width in different plants: flowers white, small, 1 cm. or less in diameter, in a simple raceme or a panicle which branches at base: pedicels spreading horizontally like candelabra, filiform, 2–4 cm. long: lowest bracts foliaceous, the upper becoming much smaller, thin and white-membranous, all attenuate: perianth with outer divisions sessile, ovate, obtuse, 4.5 mm. long, 3 mm. wide or less; inner divisions oblong, 6 mm. long or less, a little more than 2 mm. wide, the yellow claw about 1 mm. long and almost as broad; glands toothed, the teeth extending to the veins, concave on the inner side: stamens shorter than the petals, with rather thick filaments 4 mm. long; anthers cordate, 1.5 mm. long: pistils 1 cm. long, with the styles half the entire length: capsules becoming 12 mm. long, slightly narrowed at top, with styles persistent and erect: seeds 4.5 mm. long, irregular.

This elegant species was collected by the author, near the end of May, 1902, on the road between Cahto and the Eel River, Mendocino County, California, also on Red Mountain, in the northern part of the same county, at about the same time. There are specimens also in the herbarium of the California Academy of Sciences from Snow Mountain, collected by Mr. T. S. Brandegee, the twenty-first of June, from which the description of the fruit is taken.

Allium Hickmani

Small, slender plants not more than 1.5 dm. high, often 2 scapes from the same bulb or from 2 somewhat united bulbs; outer coats of bulbs with a wavy, fissile reticulation somewhat similar to *A. serratum*, but the wavy lines less zigzag: leaves filiform, longer than the scapes, 2 or 3, sheathing the stem at base below the surface of the ground: umbels generally with about 10 flowers, on slender pedicels 5–10 mm. long; bracts transparent, membranous, united at base but generally splitting down on one side, broadly ovate, mucronate, surpassing the pedicels: perianth white throughout or tinged or veined with rose-color, with all the divisions similar, ovate-lanceolate, acuminate, 5 mm. long, 2 mm. wide: stamens shorter than the divisions, the filaments narrow, flat, broadening towards the base and at the insertion extending the width of the division; anthers small, white, 0.5 mm. long: ovary without crests: seeds black, rough.

This is common on the trail between Monterey and Pacific Grove, California, and was seen in but one locality. It has been considered a form of *A. peninsulare* Lemmon by Marcus E. Jones (Contr. to Western Bot. 10: 86. 1902). While I have not seen the type of *A. peninsulare*, I do not believe it to be the same, for the description is that of a plant entirely different and the range far removed geographically. It is named in honor of Mr. J. B. Hickman, who sent me the first specimens some years ago. The type was collected by the author, April 15, 1900.

Fritillaria Brandegei

Bulb unknown: lower leaves wanting: stems apparently tall, stout, glabrous, obtusely ribbed: leaves in whorls of 5–9, lanceolate, 7–9 cm. long, 1–2 cm. wide, entire, obtuse: internodes a little shorter than the leaves: flowers about 7, on recurved, rather thick pedicels, 2 cm. long: bracts foliaceous, erect, diminishing upwards, 2–5 cm. long: perianth purplish, campanulate with obtuse base; divisions 2 cm. long, 4 mm. wide, oblong-lanceolate, becoming involute and spreading, somewhat revolute from the base, obtuse and somewhat hooded at apex and with a tuft of silky hairs: nectaries obscure: filaments spotted with purple, 2 mm. broad, 6 mm. long, acuminate; anthers sagittate, 3–4 mm. long: ovary winged, truncate, 6 mm. long: style surpassing the stamens, 1 cm. long: stigma capitate, scarcely lobed.

This is named in honor of T. S. Brandegee, who collected it at Coburn's Mills, Tulare County, California. It differs from all known species in the segments of the perianth, revolute from the base, and the broad filaments. The lobed stigma puts it into the group with *F. pudica* and *F. pluriflora*.

Iris amabilis

Rootstocks slender, sheathed with the bases of the leaves: stems simple, slender, erect, or, when tall, slightly geniculate, glabrous, bright green: basal leaves short, chartaceous; cauline leaves 2 or 3, the longest not extending to the flowers, narrow, 1.5 dm. long, 4 mm. wide, the margin with a narrow, white, minutely serrulate edge: spathes 2-flowered, the largest bract scarcely reaching the tube of the perianth, acuminate, green, with white membranous margins, the longest about 8 cm. long, inner ones shorter, more membranous: flowers on pedicels 2.5 cm. long, longer than the 3-sided, linear-oblong ovary: tube of the perianth slender, cylindraceous, 3 cm. long, widening at the throat; standards spatulate with broad claws longer than the blades and about half as wide, together 5 cm.; blade 1.5 cm. wide, pale cream or lilac-white, marked with lilac veins or dots, the central rib yellow except the upper three fourths of the blade; falls pale lilac, lanceolate, undulate, 5 cm. long, 1.5 cm. wide: style-branches 3 cm. long, with oblong crests 1 cm. long, the margins erosely dentate; scale of the stigma broadly deltoid, obtuse: stamens with broad, subulate filaments, half as long as the anthers, wider at base, together more than 2 cm.: fruit immature.

This is closely related to *Iris Douglasiana* Herb. It is readily distinguished from any of the forms of that variable species by much narrower, paler green, very sharply attenuate leaves, and much longer and more slender calyx-tube. The flowers have a delicate perfume, and in this respect it differs from all other known species in California.

This was collected by Mr. Charles W. Kitts, at Nevada City, California, May, 1902. The description was made from fresh material.

Chorizanthe villosa

Stems prostrate, spreading, forming loose mats 2–4 dm. in diameter, canescently villous throughout with fine, silky, upwardly-spreading hairs, the inflorescence glandular: leaves opposite, oblong-spatulate, tapering to long margined petioles which broaden and are connate at base, the entire leaf 2–4 cm. long: cymes pedicellate, 2 or more together, rarely solitary at the ends of short branchlets, these scattered and alternate with a solitary flower in the opposite leaf-axil or at the base of the peduncle; sometimes the solitary flower alone is present and is found at even the lowest leaf-axils: bracts at base of involucres linear, tipped with a stout straight spine which varies in length: involucres pale green, glandular as well as villous, pedicellate, urn-shaped but not constricted below the teeth, corrugated between the ribs, the alternate divisions stronger and tipped with a bristle; bristles unequal, one much longer than the rest, the others alternately shorter, glabrous at tip but villous below, rarely the longest bristle is uncinate at tip, the others are invariably straight: perigonium with stipe-like base, tubular funnelform, with yellowish green glabrous tube and six obtuse, villous divisions about half as long as the tube, pale pink with darker midnerve, oblong, mucronate: anthers pale pink, exserted from the throat of the perigonium: akenes with membranous coat, margined or slightly winged on the angles.

This is near *C. pungens* Benth., from which it differs in pubescence, involucres, spines, thick involute cartilaginous instead of membranous margins, corolla of different shape with narrower and more deeply cut lobes.

The figure of the type of *C. pungens* as shown in Trans. Linn. Soc. **17**: *pl. 19* (*2 a, b, c, d, e*), has been taken for comparison. This differs from *C. pungens* as it is understood by the authors of the present in having all the teeth of the involucre tipped with straight instead of uncinate bristles.

Chorizanthe villosa grows on the sand-dunes at Bodega Point, Sonoma County, California, and blooms in the summer.

Spraguea eximia

Winter annual or biennial from a tap-root, with a rosulate cluster of leaves from the one or more crowns, glabrous throughout: radical leaves oblanceolate, tapering to margined petioles as long as the blades, together 1–3 cm., mucronate, entire or with 1 or 2 teeth on the sides; cauline leaves spatulate, bract-like or foliaceous, scattered, from 2 mm. to 1.5 cm. long: flowering stems reddish, 3–10 cm. or perhaps more in height, the scorpioid spikes in simple or compound umbels, sometimes with a second umbel below the main one; peduncles filiform, clothed with minute, white membranous bractlets, the involucre of larger, somewhat thicker bracts; flowers crowded in short spikes at the ends of the peduncles, pedicels 1 mm. long: calyx rose-colored, membranous, broadly orbicular, 5 mm. or a little more in width, about 4 mm. in length, emarginate at apex, reniform at base, thickened near the apex, with a greenish or reddish spot: petals 4, white, membranous, elliptical, acute at apex, 4 mm. long, 2 mm. wide, the white tips surpassing the calyx at or after anthesis: stamens 3, not quite as long as the petals, the anthers white, elliptical: ovary sessile, ovate, white-membranous, showing the seeds within: style surpassing the petals; stigma 2-lobed: seeds about six, orbicular, papillate.

The short stamens separate this from *S. umbellata* Gray, to which it is allied, though differing also in other characters.

It was collected by Miss Agnes Bowman at Sulphur Banks, Lake County, California, May 18, 1901. It is a most beautiful plant, well worthy of cultivation.

Silene grandis

Stems many, knotted at the nodes, generally simple, 3–6 dm. high, growing in clumps from a thick, white, fleshy rootstock: radical leaves oblong-spatulate, acute, entire, somewhat fleshy, glandular and velvety-pubescent, with rather indistinct veins; blade 5 cm. long, 2 cm. wide, tapering to a margined petiole equalling the blade in length and 3 mm. wide, sheathing the stem; cauline leaves sessile by a connate-clasping base, oval to ovate, acute, 3–5 cm. long, 2–4 cm. wide, the chief veins distinct: flowers fascicled in the upper axils on peduncles as long as the calyx, very glandular-hairy: calyx inflated, campanulate, 12 mm. long, the 10 green ribs alternating with as many whitish furrows; divisions 5, broad, triangular, with membranous and ciliate margins: corolla greenish white, the petals with claws exserted from the calyx, 13 mm. long, tapering from a broad, membranously margined, spatulate upper part, 4 mm. wide, to a base 0.5 mm. wide; blade with two deeply parted, obtusely laciniate divisions, 6 mm. long, 4 mm. wide, with a tooth-like, narrow lobe almost at right angles and varying in length from 1–3 mm.; appendages in the throat fan-shaped, crenate, 3 mm. long and about as wide: stamens in two sets, the longer equalling the corolla-appendages, the shorter a little surpassing the styles; anthers brown; filaments filiform: ovary, petals and stamens on a disk surmounted by a yellow ring: styles 8 mm. long, glabrous except the glandular-hairy stigmatic surface: ovary glabrous.

This interesting but unattractive *Silene* grows on the sides of the promontory at Bodega Point, Sonoma County, California, looking towards the south and west. On the south side it is twice as tall as on the side where it endures the force of the west wind. It is also more abundant and in every way more luxuriant. It is probably quite local but may be found elsewhere on the coast. It is in bloom almost throughout the spring and summer.

Eschscholtzia dolichocarpa

Annual, leaves mostly radical, the flowers terminating long, subscapose peduncles, glabrous throughout except for a peculiar pubescence of tentacle-like hairs on the bases of stems and leaves: leaves pinnately dissected with the divisions narrow, petioles twice as long as the blades, together 8 cm.: peduncles stout, some 3 dm. tall: torus with membranous inner rim, the outer very narrow, revolute: buds acuminate, 2 cm. long, covered by a thin calyx: corolla yellow, the cuneate-obovate petals 3.5 cm. wide, 4 cm. long: pod stout, 1–1.5 dm. long, strongly ribbed like the peduncle of which it seems a prolongation: seeds obovoid or rhomboid.

This was collected by Mr. R. A. Plaskett at Willow Creek, near Point Gorda in the Santa Lucia Mountains, Monterey County, California, April 8, 1898, being no. 84 of his collection.

It is readily distinguished from allied species by the large flowers and remarkable pods and peduncles.

Eschscholtzia urceolata

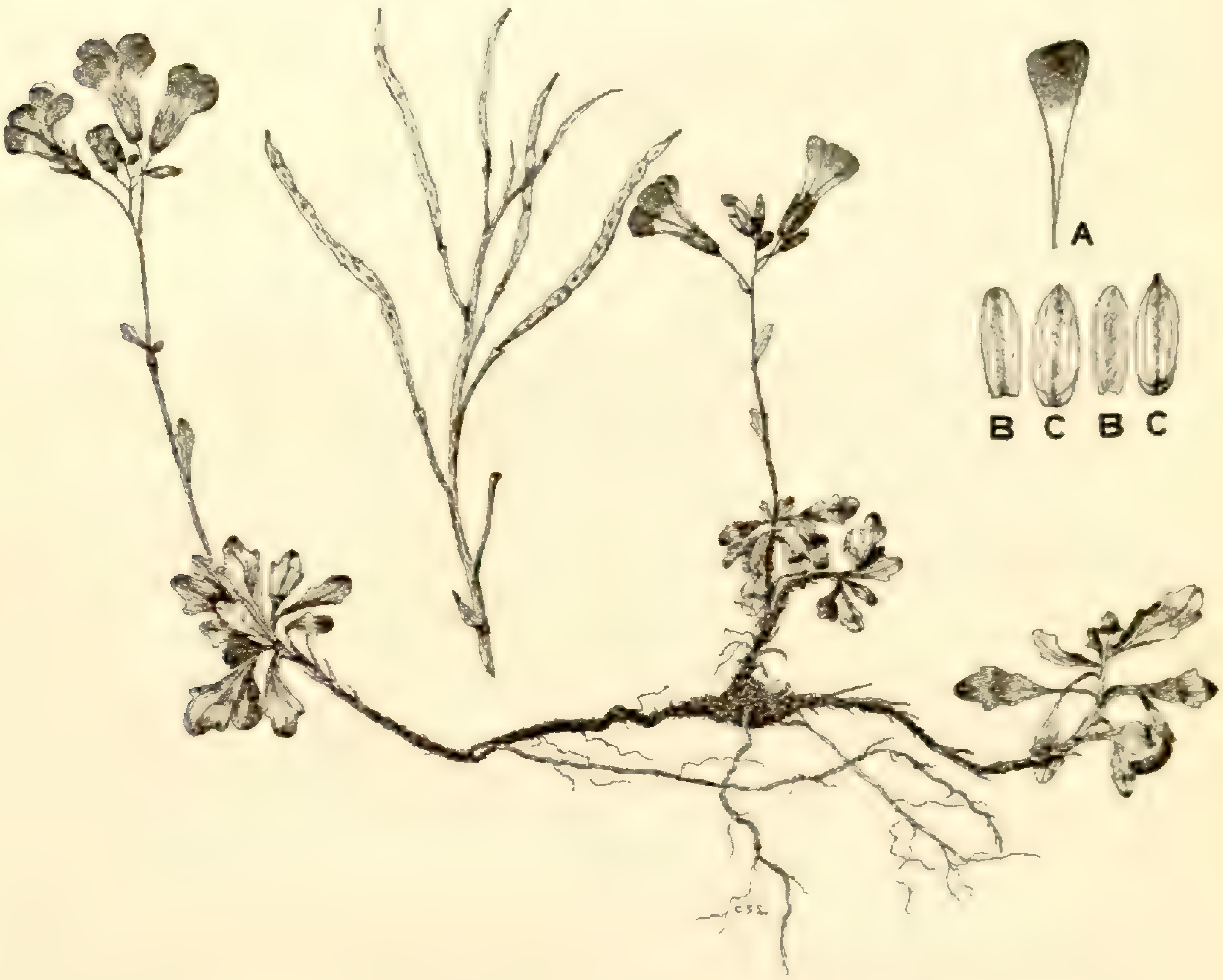
Annual, many-stemmed, 1–2 dm. high, glaucous and glabrous except for a scattered pubescence of peculiar tentacle-like hairs, generally on the young growth, the lower part of the stems and leaves and the buds: leaves shorter than the scapose peduncles, with the slender petiole generally surpassing the pinnately trisected blade, together 3–8 cm. long, the ultimate divisions linear, obtuse or rarely mucronate, 2–5 mm. long: earliest flowers on long stout, ribbed, scapose peduncles, 1–1.5 dm. long, the later ones on leafy stems: buds drooping: calyx thin, ovate, about 1.5 cm. long, obtuse, sometimes glabrous: corolla yellow, the cuneate-obovate petals 2.5 cm. long, and almost as wide at the top: stamens about 1 cm. long, the filaments somewhat shorter than the narrowly linear anthers: styles 4, varying in length, minutely papillate: pod stout, ribbed, acuminate, about 6 cm. long: receptacle urceolate, 7 mm. long, the outer rim lacking, the inner white, membranous, erect.

This beautiful species was collected by the author on the white hills separating the valley of the Cuyama from the Carisa Plains on the boundary between Santa Barbara and San Luis Obispo Counties, California, May 2, 1896.

It is related to *E. hypecoides* Benth., but is distinctly differentiated from that and other allied species by the peculiar shape of the torus.

Arabis McDonaldiana

Stems many, 5 mm. to 2 cm. high, from a branched caudex, forming mats, slender, glabrous: leaves rosulate at base, spatulate, repandly toothed, the few teeth sometimes bristle-tipped; blades 5–10 mm. long on margined petioles as long or longer, broadening at base and imbricated: cauline leaves few, 5 mm. long, from spatulate to narrowly oblong, obtuse, sessile, appressed to the stem, entire or with obtuse teeth: flowers corymbose, fragrant: sepals greenish or purplish black, two narrowly oblong, obtuse, 4 mm. long, 1–1.5 mm. wide, the other two broader, spurred at base, membranously margined: petals crimson, oblanceolate, tapering to the base with the distinction between blade and claw not evident, truncate or obtuse at apex, 9 mm. long, about 3 mm. broad: stamens with ribbon-like filaments, the longest as long as the sepals; anthers narrowly oblong, yellow, 1.5 mm. long: siliques 3–4 cm. long, erect-spreading, becoming racemose with pedicels 1 cm. long: style 1 mm. long.



Arabis McDonaldiana. *A*, petal. *B*, inner sepals. *C*, outer sepals.

This beautiful and fragrant *Arabis* was collected by the author in the northern part of Mendocino County, California, on Red Mountain, May 26, 1902. It is named in honor of Captain James M. McDonald, to whom botanists of the Pacific coast are indebted for his generosity in publishing Greene's West American Oaks and the author is personally grateful for aid in her work.

It is allied to *Arabis blepharophylla* H. & A., from which it differs in shape and size of leaves, almost complete absence of pubescence, smaller flowers and longer and more slender pods. These differences are added to a general dissimilarity in appearance, so that the two species would never be confused, though the flowers have the same color and fragrance.

Cleomella nana

Annual, low, 3–8 cm. high, simple or branching from near the base, the branched plants having a diameter about equal to the height; stems striate with fine broken lines and occasionally verrucose, glaucous: leaves trifoliate, the petioles generally shorter than the petiolulate leaflets; stipules tufts of hairs; leaflets narrowly oblong-lanceolate, the lateral 6 mm. long, the middle 9 mm., 2–3 mm. wide, aristate, tapering at base, entire but somewhat revolute, midvein distinct, surface (under a good lens) covered with minute reticulation: flowers in sessile racemes on spreading pedicels 5–10 mm. long; lowest bracts like the leaves, upper like the stipules: calyx of 4 subulate-aristate divisions 1.5 mm. long, stipe with a bulb-like swelling at base, deflexed, becoming 6 mm.: petals yellow, oval, 4.5 mm. long, 2 mm. wide, obtuse, subsessile: stamens surpassing the petals, the filaments 10 mm. long; anthers linear, mucronate, almost 2 mm. long: style 1.5 mm. long, stigma 2-lobed: capsule when young rhomboidal, later becoming more ovate, not winged, minutely reticulated, 5 mm. wide, 4 mm. long: seeds 2, yellow-brown, suborbicular, 2 mm. in diameter, flattened, the outer coat transparent so that the space between the caulicle and the cotyledons is visible and resembles the mouth of a fish.

This interesting *Cleomella* was collected by the author, May 24, 1892, between Thompson's Wash and Moab, in southeastern Utah. It is near *C. obtusifolia* Torr. & Frém., but differs in habit, flowers, and fruit. The strongly-winged fruit of *C. obtusifolia* presents an entirely different appearance.

Wislizenia scabrida

Annual, erect, branching divaricately from the base and also above, 3 dm. or more in height, rather stout, scabrous throughout; stems purplish, ribbed: leaflets 3 or rarely 4, obovate or elliptical, glaucous on the lower surface, bright green on the upper, retuse and aristate, 2 cm. long, 1 cm. wide, with petiolules 2 mm. long; petioles generally shorter than the leaflets; stipules a tuft of bristles: racemes elongating in fruit, corymbose in flower, short-pedunculate; pedicels as long as the stipes, curving outwards, the stipes deflexed toward the stem: sepals ovate, tipped with a slender bristle of the same length, at length deciduous: petals yellow, oblong-ovate, 4 mm. long, 2 mm. wide, obtuse, sessile: filaments 8 mm. long, anthers linear, a little more than 1 mm. long, mucronate: ovary with 2 ovules in each cell: style curved, 3–4 mm. long: capsules horizontal, castle-shaped, tuberculated at summit, ribbed about the middle, but smooth on the lower third: seeds 1–2 in each cell: pods deciduous from the axis, leaving a perforation at base.

This was collected at Tucson, Arizona, August 20, 1894, by J. W. Toumey, who distributed it as *W. refracta* Engelm. It differs from this species in the scabrous pubescence and the shape and position of the two parts of the fruit. It is also related to *W. Palmeri* Gray but differs in the shape of leaves and fruit.

Lathyrus Brownii

Perennial from slender, running rootstocks, with stems apparently erect, climbing, 1–2.5 dm. high, glabrous throughout and glaucous, striate but scarcely angled: leaflets 4–8, opposite, elliptical to narrowly oblong, pale green on both sides, the younger ones somewhat glaucous, veiny, glabrous, 1–2 cm. long, 5–9 mm. wide, aristate; petiolules 1 mm. long, petioles 5–10 mm.; stipules semi-sagittate, entire or with few teeth, acuminate at each end, the lower part slightly shorter than the upper, 10–14 mm. long, about 3 mm. wide: tendrils abortive and reduced to a short bristle, or short and bifurcate: peduncles equalling or shorter than the leaves, spreading or declined, terminated by 2–3 violet flowers: calyx 7 mm. long, glabrous except for the ciliate margins, the two upper teeth deltoid, separated by a broad sinus, the three lower about twice as long, subulate, the middle division narrowest and 2-toothed at apex: corolla 1.5 cm. long, thin in texture; banner with sides reflexed, 12 mm. wide when spread out, twice as broad as deep, the claw 7 mm. long, 9 mm. wide; wings 6 mm. broad, surpassing the keel by 3 mm., with a claw 7 mm. long: stamineal tube 2 mm. in diameter, loosely surrounding the ovary: pistil with incurved style hairy for half its length; ovary smooth, containing about 12 ovules.

This was collected in 1890, on the north side of Mount Shasta, by H. E. Brown, in whose honor it is named. It is no. 391 of his collection.

This species is readily distinguished from other Californian species to which it is allied by the rudimentary tendrils, pale glabrous foliage, and few-flowered racemes. It seems nearest to *L. palustris* L.

✓ Clarkia parviflora

Stems clothed with white, smooth, shining, shreddy epidermis, simple or with upwardly spreading branches, 4–8 dm. high: leaves linear, tapering to a nerved petiole, acute, entire, puberulent, the longest 7 cm. long, 3 mm. wide: flower and buds nodding, the latter acuminate at each end and scattered: calyx-tube short, rather narrow, with the divisions united to one side by the tips: petals crimson or magenta, narrowly cuneate, bilobed at apex, 6 mm. long, 3–4 mm. wide, with clustered hairs at base: stamens with yellow anthers, all eight fertile, in two sets, the longer equalling the petals: style surpassing the stamens, with long, reflexed stigma-lobes: ovary sessile, curved downwards at first but becoming erect, quadrangular, acuminate with the pointed part one half to one third the entire length: seeds not ripe.

This approaches *C. Xantiana*, but has much smaller flowers, nodding instead of erect. It was collected at Kernville, Kern County, California, by Mr. T. S. Brandegee, May 13 (the year is not given).

✓ Scutellaria Nevadensis

Rootstocks moniliform: stems numerous from the base, purplish, cinereous with fine, short, curled, closely appressed pubescence, from less than 1 to 2 dm. high, slender, leafy and floriferous from almost the first leaves; internodes shorter or longer than the leaves; leaves ovate to elliptical, the cuneate base tapering to a petiole from 0.5–5 mm. long, obtuse, truncate or emarginate at apex, entire, 3–5-nerved from the base, the lowest 1–2 cm. long, diminishing upwards, 5–10 mm. wide: peduncles slender, about as long as the calyx: calyx large and conspicuous on account of the broad, wing-like crest, which surpasses the truncate entire tube, enlarging from 3 mm. in flower to 7 mm. in fruit: corolla purple, about 2 cm. long, the tube straight, moderately enlarging at the throat, with the two lips almost equal; the upper rounded, obtuse, the two lobes at the sides reflexed; the lower broader, crenately lobed, sparingly hairy within: filaments curved at apex; anthers ciliate, with emarginate apex and cordate base: nutlets covered with tentacle-like tubercles, turbinate.

This seems nearest to *S. nana* Gray, which it resembles in the pubescence and rootstocks, and more or less in the floral organs. It is different in every way; shape of leaves, size and shape of flower, stamens and seeds.

The type was collected by P. Beveridge Kennedy, of the University of Nevada, at Little Lakes Cañon, Western Stampede, Elko County, Nevada, July 1, 1902, being no. 546 of his collection, also no. 502 from the same locality, June 13, 1902.

Scutellaria linearifolia

Stems about 1 dm. high, slender, simple or branching from the base with erect branches, purplish brown at base: leaves linear with the edges folded backwards, 1–2 cm. long, 1–2 mm. wide, tapering to a sessile or short-petioled base, obtuse at apex, minutely and closely pubescent: flowers erect on filiform, spreading pedicels 5 mm. long, equal in length to the calyx: calyx with pubescence similar to that of the leaves, with shallow lobes and conspicuous crest: corolla 2.5 cm. long, the tube curving like the neck of a swan, throat moderately ampliate; upper lip 3-lobed, the middle lobe curved, the lateral lobes truncate, recurved; lower lip erect, not spreading, hairy within: stamens with filaments curved at top; anthers ciliate, the two cells spreading from the top: fruiting calyx apparently nodding.

This species is distinguished from *S. angustifolia* Pursh, under which it was placed, by much narrower leaves and flowers of quite a different shape. The type was collected at San Diego, California, June, 1876, by W. J. Fisher, being no. 586 of his collection. This is the only specimen seen.

Scutellaria Austinae

Stems erect, with ascending branches from near the base and sometimes above, purplish at base, glabrous to puberulent, slender, 1–2 dm. high: leaves erect, linear-oblong, entire (lowest spatulate), 2–3 cm. long, 3 mm. wide, the upper sessile, the lower on short petioles, closely pubescent, with prominent midvein, obtuse or acute at apex, tapering at base, generally twice as long as the internodes: flowers purple, erect, in the upper axils, 2–5 cm. long, on filiform pedicels as long as the calyx (3–4 mm.), erect-spreading: calyx minutely and closely pubescent, with shallow lobes and conspicuous crest tinged with purple: corolla purple, the tube slender; upper lip 3-lobed, with the lateral lobes folded backwards, the middle lobe longest, galeate and truncate; lower lip spreading, hairy in the throat: stamens exserted, with filaments curved under the anthers; these emarginate at apex and base, ciliate: nutlets unknown.

This is related to *Scutellaria angustifolia* Pursh, under which it has probably been included. It has much smaller flowers than that and an altogether different appearance.

The type was collected by Mrs. C. C. Bruce at Big Chico, Butte County, California, May, 1897, being No. 1835 of her collection. It is named in her honor and that of her mother, Mrs. R. M. Austin. With it I would also put no. 221 of the collection of H. E. Brown from Pitt River, Shasta County, also a specimen collected by Mrs. A. L. Coombes at Baird in the same county and one collected by the author between Shasta and Redding. There is another specimen, collected by the author on the road between Lewiston and Weaverville, Trinity County, which is doubtfully placed here. It has leaves longer and narrower and flowers not so spreading at the throat.

Fraxinus macropetala

Shrub, with ash-colored bark on the branchlets: leaves 3–5-foliolate, the terminal leaflet much larger than the lateral, obovate to broadly oval and orbicular, tapering at apex and base, decurrent on the petiolule, sometimes obtuse and truncate, entire or crenate, serrulate, 1.5–3 cm. long, 1– almost 2 cm. wide, the petiolule about half as long; lateral leaflets about one half the size of the terminal, obovate to lanceolate, the petiolules much shorter; the minute dark glands numerous, the pellucid ones few; surface glabrous or the petioles and rachis slightly scaly-puberulent: flowers perfect, in panicles terminating the branchlets; panicles erect in flower, pendulous in fruit, the peduncles and pedicels filiform, the latter shorter than the fully developed flowers: calyx with attenuate divisions unequal, equalling or longer than the campanulate tube, together 1.5 to 2 mm.: corolla green at first, becoming white, 12 mm. long, the four linear, involute divisions three times as long as the narrow tube: stamens 2, inserted at the base of tube, not reaching to the top, the brown linear-oblong anthers almost twice as long as the filaments, 2 mm.: ovary tipped by a short thick style: fruit linear-oblong, 2–2.5 cm. long, 5 mm. wide, the wing extending half way along the sides of the seed, about as long as or slightly longer than the kite-shaped seed, emarginate at apex, often tipped by the short persistent style.

This comes nearest to *F. cuspidata* Torr., but differs in the shape of the leaves and the longer fruit which is contracted somewhat at base. The calyx is different and the divisions of the corolla are much longer.

This was first collected by E. O. Wooton, July 9, 1902, in the Grand Cañon of the Colorado, being no. 1102 of his collection; this specimen is in fruit. The flowers were collected at the same place, on the Bright Angel Trail, by Dr. C. Hart Merriam, the middle of May, 1903. These specimens are both in the Herbarium of the California Academy of Sciences.

✓ Convolvulus saxicola

Low, trailing, glabrous throughout: stems, peduncle, and petioles striate: leaves veiny, deltoid-sagittate with the apex rounded and mucronate, basal lobes overlapping, rarely with a broad sinus and the lobes separated, undulate, about 3 cm. long and as broad at base; petioles slender, 2–4 cm. long, surpassing the rather stout 1-flowered peduncles: bracts variable, sagittate, from very small and sessile to foliaceous, petioled and surpassing the bud, generally close to the flower: calyx with the outer sepals half as long as the inner, about equally broad, obtuse, truncate or emarginate, occasionally mucronate, sometimes almost membranous: corolla pale rose-colored with the angles darker: stigmas slightly surpassing the anthers: ovary with a hard dome-shaped top, tipped with a short stout spine, veiny, purplish where it joins the thin, green lower half: immature seeds black, irregularly angled, minutely papillose.

This grows on the rocky summits of the more elevated parts of Bodega Point, Sonoma County, California, and was collected by the author in April and on July 4, 1900.

It is near *C. polymorphus* Greene (Pitt. **3**: 331) and might be included in the aggregate of forms under *C. luteolus* Gray.

✓ Sphacele Blochmanae

Shrub 1 m. high, or more, forming a clump: older stems clothed with a red-brown epidermis which becomes shreddy; upper part brown or greenish, glandular and clothed with spreading, jointed, simple or forked hairs: leaves shorter or longer than the internodes, the lowest most distant, ovate-elliptical, 3–8 cm. long, 1–4 cm. wide, obtuse, cuneate at base and decurrent, crenate or obscurely serrate, upper surface green, somewhat scabrous-pubescent and glandular, the lower cinereous or white-tomentose with more numerous glands, veiny and becoming rugose; petioles broad, margined, the lower 1 cm. long or more, the upper leaves sessile: branchlets terminating in a simple raceme or a 3-rayed cymose panicle, the flowers often secund, with short slender pedicles; lower bracts leaf-like, the upper green on both sides, ovate, clasping by a cordate base, acute, 2–10 mm. long: flowering calyx campanulate, rounded at base, 12–15 mm. long, with deltoid divisions less than 5 mm. long, sharply acute, hispid and glandular; fruiting calyx becoming more than twice as large, chartaceous and very veiny: corolla tinged with violet, 2.5 cm. long, the tube gradually enlarging from 2 mm. at base to 8 mm. at throat; upper lip 1 cm. wide, 6 mm. long; lower lip of 4 broad nearly equal lobes, 5 mm. wide, 3 mm. long: anthers obtuse, deeply sagittate, connected to the filament near the top, the body brown with the cells white; nutlets black-brown, globular, sparsely hispid.

This was collected by the author July 10, 1902, along the road on the hills not far from Pozo, on the road to La Panza, in San Luis Obispo County, California. The shrubs grew near a spring and were seen in only one place, though they were quite abundant and attracted attention at once from the difference in appearance to the other species. Compared with *S. calycina* Benth., the common species and that which it most resembles in general appearance, the leaves are dissimilar in shape and the flowers are quite unlike. In *S. calycina* the calyx is cuneate at base, in this obtuse; the corolla of this is only about half as broad as in the other and quite different in shape; the divisions of the calyx are shorter and less pointed.

This species is named in honor of my friend Mrs. Ida M. Blochman, whose kindness enabled me to collect the plants of this region and who has done much to make known the plants of the country around Santa Maria, California.

✓Monardella tomentosa

Stems several from a suffrutescent base, slender, hairy-tomentulose, 3 dm. high: leaves ovate-lanceolate, about 2.5 cm. long, 1 cm. wide, somewhat obliquely cuneate at base, obtuse at apex, more densely tomentose on the lower than the upper surface, principal veins evident; petioles 5 mm. long, becoming shorter towards the inflorescence: flowers capitate in a single terminal cluster, or with a few smaller heads in the upper axils subtended by 1–2 pairs of leaves as well as the involucral bracts; these ovate, 1 cm. long, tomentose and veiny but not membranous: calyx tubular, 8 mm. long, tapering at base, broadest near the middle, with 11 ribs, 5 subulate teeth 2 mm. long, tomentose throughout: corolla deep lilac, hairy, with the tube exserted 4 mm., the divisions ribbon-like, the two upper ones cleft to below the middle, the three lower almost to the base : filaments slender, hairy below the middle ; anthers white : style surpassing the stamens : nutlets immature.

This was collected by the author at Laytonville, Mendocino County, California, Aug. 2, 1902.

It comes in the aggregate under *M. villosa*, but is quite unlike the type of that species as judged by a specimen collected at Bodega Bay, the type locality, which agrees exactly with the figure in Bot. Sulph.

✓**Lappula micrantha**

Stems leafy, branched from the woody root and paniculate above, about 5 dm. high : radical leaves oblong-lanceolate, some almost 2 dm. long, including the long margined petioles, canescent with appressed hairs ; upper leaves sessile, much shorter, about 5–10 cm. long, with apex mucronate or obtuse and margin entire : panicle loosely flowered, with open, spreading branches, the lower peduncles long, slender and naked, flowering at the end, the upper flowering almost to the base ; pedicels slender, as long as the calyx, deflexed after anthesis : divisions of calyx oblong-elliptical, obtuse, about 2 mm. long : corolla with tube shorter than the calyx, lobes obtuse, a little more than 1 mm. long, shorter than the tube, the yellow crests in the throat conspicuous : anthers about as long as the filaments, extending to the crests : style filiform, tipped by a capitate stigma : gynobase low, pyramidal : nutlets ovate, 5 mm. long, the ventral surface with an ovate scar with lines radiating from it to the margin, both sides bristly or scabrous ; margin edged with purple subulate awns, 3 mm. long, 1.5 mm. wide at base ; these large awns often with smaller awns at the sides and always with shorter ones alternating ; at the middle of the dorsal surface a solitary rather large awn projects.

This differs from all the described species in having much smaller flowers and in different character of the nutlets. The type was collected by the author at Twin Lakes, Trinity County, California, July 9, 1901. It grew along the banks of a small stream flowing from one of the high peaks into Cañon Creek.

✓**Symphoricarpos glaucus**

Shrub, with reddish brown epidermis, the older shreddy, the younger reddish and as if covered with a bloom, the pubescence of fine curly hairs : leaves glaucous, with pubescence like the stems, rhombic-obovate, the apex obtuse or callous-mucronate, at base tapering to short connate petioles, margins thickened, entire or with a few obtuse teeth near the apex, strongly veined, the lower surface somewhat paler than the upper, 2–3 cm. long, 5–12 mm. wide: flowers in the axils of the upper leaves, with ribbed pedicels about as long as the bracts, bent so that the flower is horizontal or pendent: bracts at base of ovary ovate-acuminate, hairy, from one half to almost as long as the ovary: calyx purplish or glaucous, 2 mm. long, with the deltoid divisions half as long, obtuse, edged with white, minutely ciliate: corolla white or rose-colored, tubular-funnelform, about 1 cm. long, about 5 mm. wide at the tube, hairy within from the throat to the glandular lower part which is 2 mm. from the base: stamens with rose-colored, narrowly oblong, versatile anthers, on filaments half their length, inserted in the throat of the corolla: pistil not extending to the stamens, with thick glabrous style, 4 mm. long, tipped by a greenish black stigma: ovary oblong-elliptical in outline, glaucous, 3 mm. long, not conspicuously narrowed at the two ends.

This distinctly marked species is related to *S. rotundifolius*, under which it may have perhaps been included, but with the original description it does not agree. It was collected by Professor P. B. Kennedy of the University of Nevada, June 13, 1902, in Little Lakes Cañon, Western Stampede, Elko County, Nevada, being no. 503 of his collection.

Symphoricarpos parvifolius

A low, intricately branched shrub, with shreddy bark, the young twigs filiform, reddish, clothed with fine spreading pubescence: leaves thin and veiny, rhomboidal to elliptical, glaucous and with a fine spreading pubescence, acute, tapering at base to a short petiole, entire, 5–10 mm. long, 3–5 mm. wide; petioles broad and hairy: flowers in the upper axils on straight or curved pedicels, 1 mm. long: bracts at base of ovary pubescent, ovate-acuminate, connate: calyx crateriform, with glaucous, deltoid, acute divisions as long as the tube, glabrous, ciliate: corolla rose-colored, tubular-funnelform, 6 mm. long, tapering gradually from the top, 5 mm. across, to the base about 1 mm.; the tube hairy within from the base of the stamens to within 1 mm. of the base of the tube: stamens inserted in the throat, with the filaments shorter than the exserted anthers: style glabrous, 2 mm. long, with capitate stigma: ovary 2 mm. long, contracted at each end, glabrous.

This was collected on rocky slopes near Hockett Meadows, Little Kern River, Tulare County, California, June, 1896, by C. A. Purpus, being no. 1792 of his collection. It differs from allied forms in the greater delicacy of all its parts, but in general most closely approaches *S. glaucus.*

✓ Symphoricarpos Austinae

Erect shrub, the older stems clothed with a gray-brown shreddy epidermis, the younger slender, reddish, puberulent, leafy: leaves ovate to elliptical, obtuse or acute at apex, obtuse, acute or cuneate at base, 1–2 cm. long, 7–12 mm. wide, the margins entire, thickened; pubescence similar to that of the stem; petioles 2 mm. long: flowers in the axils of the upper leaves and in short cymose clusters or umbels, erect or nodding at the ends of the branchlets, with the pedicels horizontal or downwardly curved; bracts half as long as the ovary, ovate, acute, pubescent and ciliate: calyx 1.5 mm. long, the divisions deltoid, obtuse, as wide as long and half the entire length of the calyx, glabrous or very sparsely pubescent, ciliate: corolla tubular-funnelform, 9 mm. long, 4–5 mm. across the top, about 2 mm. at base, the lobes suborbicular, 2.5 mm. long, almost as wide, obtuse, subcordate at base; tube densely hairy within from 2 mm. below the throat to within 2 mm. of the base; anthers narrowly oblong, 1.5 mm. long, a little shorter than the filaments, exserted from the throat: style glabrous, 3 mm. long, with capitate stigma: ovary glabrous, 3 mm. long, 1.5 mm. broad at the middle, tapering to both ends: fruit immature, oblong-elliptical.

This is distinguished from allied forms by the long ovary tapering at both ends, the stamens and the position of the hairs in the tube of the corolla. It was collected on hills in Modoc County, California, by Mrs. R. M. Austin, in 1897, also on hills west of Goose Lake. Mr. T. S. Brandegee collected the same at Milford, Lassen County, June 26, 1892.

✓ Symphoricarpos glabratus

Shrub, divaricately branched, with brown shreddy bark on the older stems, the younger twigs slender and reddish, glabrous throughout: leaves orbicular, obtuse or cuneate at base, mucronate or obtuse at apex, irregularly crenate-dentate or entire, conspicuously veiny, about 1.5 cm. in diameter; petioles yellow, broadening at the connate base, about 2 mm. long, enclosing the conspicuous pointed buds: flowers solitary in the upper axils and in short spikes terminating the branchlets; pedicels erect or curved, generally longer that the bracts; these broad and connate, obtuse, minutely ciliate, about 1 mm. long and as broad: calyx crateriform, a little more than 1 mm. long, with broadly deltoid obtuse divisions scarcely half as long as the tube: corolla rose-colored, tubular-funnelform, 1 cm. long; lobes rounded, as broad as long, subauriculate at base; tube slightly hairy about the middle, glandular on the lower third: stamens exserted from the throat, the filaments half as long as the reddish, oblong, versatile anthers: style glabrous, 4 mm. long, with red, capitate stigma: ovary glabrous, oblong, not narrowed much at the two ends: fruit (immature) the same shape, but larger.

This was collected by the author at Trinidad, Colorado, June, 1891. It probably forms part of the aggregate included under *S. rotundifolius* Gray. It is quite unlike any other form which might be so included and does not agree with the original description of that species.

Echinocystis scabrida

Stems climbing by numerous branched tendrils, deeply and obtusely ribbed, glabrous or with a pubescence of scattered woolly hairs: leaves 5–7 lobed with triangular lobes less than half the length of the leaf, entire or with an occasional aristate-tipped tooth, the lobes terminating in a slender, rather long bristle; upper surface scabrous, lower with pubescence like the stem, general outline orbicular, or wider than long, but varying much in size; petioles generally longer than the leaves, broadening at base, ribbed: flowers white; the staminate in racemes, rotate, scabrous on the inner surface and with a few scattered hairs on the outer, 2 mm. in diameter; column of stamens short and thick: pistillate flowers 12 mm. in diameter, the lobes deeper than in the staminate flowers and with similar pubescence: stigma broad, sessile: ovary orbicular-ovate with a beak only 2 mm. long, tapering gradually, clothed with short weak bristles, containing 4 loculi, each with one ovule: bristles on the fruit flattened, weak, clothed with scattered woolly hairs, the surface below the bristles scabrous: seeds only one or two maturing, flattened-orbicular.

This is near *E. fabacea* Naud., but differs in the smaller, less spiny fruit, 4-celled instead of 2-celled ovary and the short instead of long beak to the ovary. It was collected by Mr. T. S. Brandegee in Fresno County, California, at Zapato, Chino Creek, March 26, 1893, and also at Alcalde in the same region.

Nemacladus gracilis

Sparingly pubescent and diffusely branching, 1 dm. high; stems very slender, more or less zigzag: radical leaves spatulate, coarsely dentate, together with the broad petioles 5–8 mm. long; cauline leaves fleshy, entire, involute, appearing terete, falcately recurving, 1–5 mm. long: flowers very numerous, on capillary pedicels which are recurved-spreading but with the flowers erect, forming a graceful double curve: fruiting calyx with the divisions 3 mm. long, similar to the cauline leaves, tube 2 mm., obconic, veiny, in flower 1 mm. and as long as the divisions: corolla campanulate, with oblong, obtuse divisions twice as long as the broad tube: stamineal column curved, with the anthers drooping after anthesis, white-hairy at apex, about 1 mm. long: stigma globular, glabrous: capsule shorter than the calyx, acute, half adnate to the calyx-tube: seeds numerous, reddish-brown, oblong, tapering to the white funiculus.

This is distinguished from other species by the double curve of the capillary pedicels, the large calyx, the peculiar corolla and the hairy apex of the style.

It is found in the hot interior valleys of the Coast Mountains. The type was collected by the author at Alcalde, Fresno County, California, May 9, 1893. There are two specimens in the herbarium of the Academy from San Luis Obispo County, one collected by L. Jared at Estrella, the other by the author at Santa Margarita, June 10, 1902.

Agoseris maritima

Caudex much branched from a perennial, woody root, crowned with leaves in close clusters, and ragged below with the imbricated, brown sheaths of dilated bases of old petioles: entire plant cinereous or tawny with soft closely appressed, curly, jointed hairs which become arachnoid on the petioles, scapes, and involucres: leaves oblong-spatulate, tapering to a margined petiole about equalling the blade, together 2–8 cm. long; blades 1–2 cm. wide, with venation not evident except the broad midrib, margin sinuate-dentate or entire, apex acute or mucronate; petioles clasping by the dilated base, becoming brown and membranous: scapes many, deeply ribbed, 5–15 cm. tall, lengthening in fruit, weak: heads 1.5 to 2.5 cm. high: rays yellow tinged with purplish brown, the five narrow teeth at the apex closely folded in the bud and forming a brown ball at the tip of each ray: bracts of the involucre densely arachnoid at base, in four series, the two outer 4 mm. broad, oblong, acute, arachnoid within at the tip, the inner linear-acuminate, foliaceous and arachnoid at tip, membranous below, surpassing the pappus in fruit, reflexed when the seeds have fallen, leaving the convex, muricate receptacle exposed: pappus pure white, upwardly barbellulate, two thirds as long as the akene; this with ten strong ribs, tapering to the disk-like summit, the beak from one fourth to one half as long as the akene, together about 4 mm. long.

This is peculiar among Pacific Coast species in having the akene tapering to a beak. Under the genus *Troximon* in Gray's Synoptical Flora this would come under the section *Eutroximon.*

The type was collected at Bodega Point on the cliffs above the ocean, looking towards the west. It was in bloom in April and again in July and appears, like so many plants on the Pacific Coast, to be a plant that blooms throughout the year.

Crepis Cusickii

Stems erect, simple or branching from the base and below the middle, striate, 3 dm. high, sparingly floccose-tomentose, and with some gland-tipped hairs which become more numerous on the upper part: radical leaves oblanceolate-oblong, with broad margined petioles as long as the blade, together 1.5 dm. long, sheathing at base; blade laciniately dentate to entire with apex acute, base tapering to the petiole, 2–4 cm. wide; cauline leaves similar but sessile, diminishing upwards, the lower entire to laciniately dentate, the upper from dentate to entire, apiculate, tapering to a clasping base, sparingly ciliate: flowering stems with 2–4 heads cymosely branched and terminating stout peduncles, the earliest shortest; bractlets few, narrowly subulate-attenuate, as long as the outer involucral scales: heads 2 cm. high, the involucral scales in two ranks, the outer 3 mm. long, the inner more than 1 cm., with green central portion and membranous margin: rays 4–6, yellow, turning white in fading, edged with short obtuse linear teeth, each tipped with a tuft of white wool: pappus soft, white, capillary and barbellate: akenes 10-ribbed, oblong, tapering but slightly at each end, glabrous.

This was collected by William C. Cusick, July, 1902, on the western slope of the Cascade Mountains, near the southern boundary of Oregon. It is no. 2872 of his collection.

CALIFORNIA ACADEMY OF SCIENCES.

Some Correlations of Leaves

By Daniel Trembly MacDougal

As a result of a long series of experimental tests made in the New York Botanical Garden, Mr. Charles Zeleny has found that the excision of one of the leaflets of such plants as *Trifolium pratense* (clover), *Parthenocissus quinquefolia* (Virginia creeper) and *Lupinus albus* (white lupine) resulted in alterations in the positions of the remaining leaflets, alterations in the intervals between the remaining members and divergences from the normal size.

Our knowledge of correlations at the present time would lead to the expectation that organs, the activity of which was complementary or dependent upon a removed organ would show a decreased or diminished development. On the other hand the small amount of evidence available would have led to the generalization that the loss of an organ or a part of an organ would stimulate the development of the remainder of the organ, or of the tissues carrying on the same function, in a supposed effort to bring the total functional performance up to the normal average. Mr. Zeleny's results, however, demonstrate unequivocally that the excision of a leaflet in the above species is followed by a diminished development on the part of the remainder, which results in the accomplishment of a superficial extension, as represented by the length of the members, about seven per cent. less than the normal.* Results fairly in agreement with those of Mr. Zeleny have also been obtained by Nemeč by less exact methods.†

Goebel cites the fact that the stipels of the compound leaves of *Robinia Pseudacacia* (locust) reach an abnormally large size when the leaflets are removed, which is an example of the induced enlargement of a structure in the effort to carry out the functions of lost tissue.‡ He has also found that the destruction of the vegetative points on such leaves as those of *Bryophyllum* is followed by the formation of new ones at places nearer the base of the leaf-blades.* It is evident therefore that the epipodium, or laminar portion of the leaf, is capable of the most diverse correlative reactions according to the structure, and adaptive, or secondary functions it has acquired.

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* Read before the Botanical Society of America, Pittsburg, July 1, 1902. Now in press in Bull. N. Y. Bot. Garden, vol. 3, no. 9.

† Nemeč, B. Ueber die Folgen einer Symmetriestörung bei zusammengesetzten Blättern. Bull. Internat. Acad. Sci. Bohême. 1902.

‡ Goebel. Organography of Plants, 1 : 210. 1900.

The lack of uniformity in the facts at hand suggested that a repetition of some of the experimental tests with additional species might yield results of value. To this end the author made a series of observations upon the effect of the removal of the epipodium and mesopodium of the leaves of one species upon the stipules of the hypopodium and upon the vegetative points of the stems from which the leaves arose. Additional observations were carried out on the influence of the removal of a leaf showing only a distinct mesopodium (petiole) and epipodium (lamina) upon the vegetative points of the stem and upon the development and differentiation of the tissues of the stem.

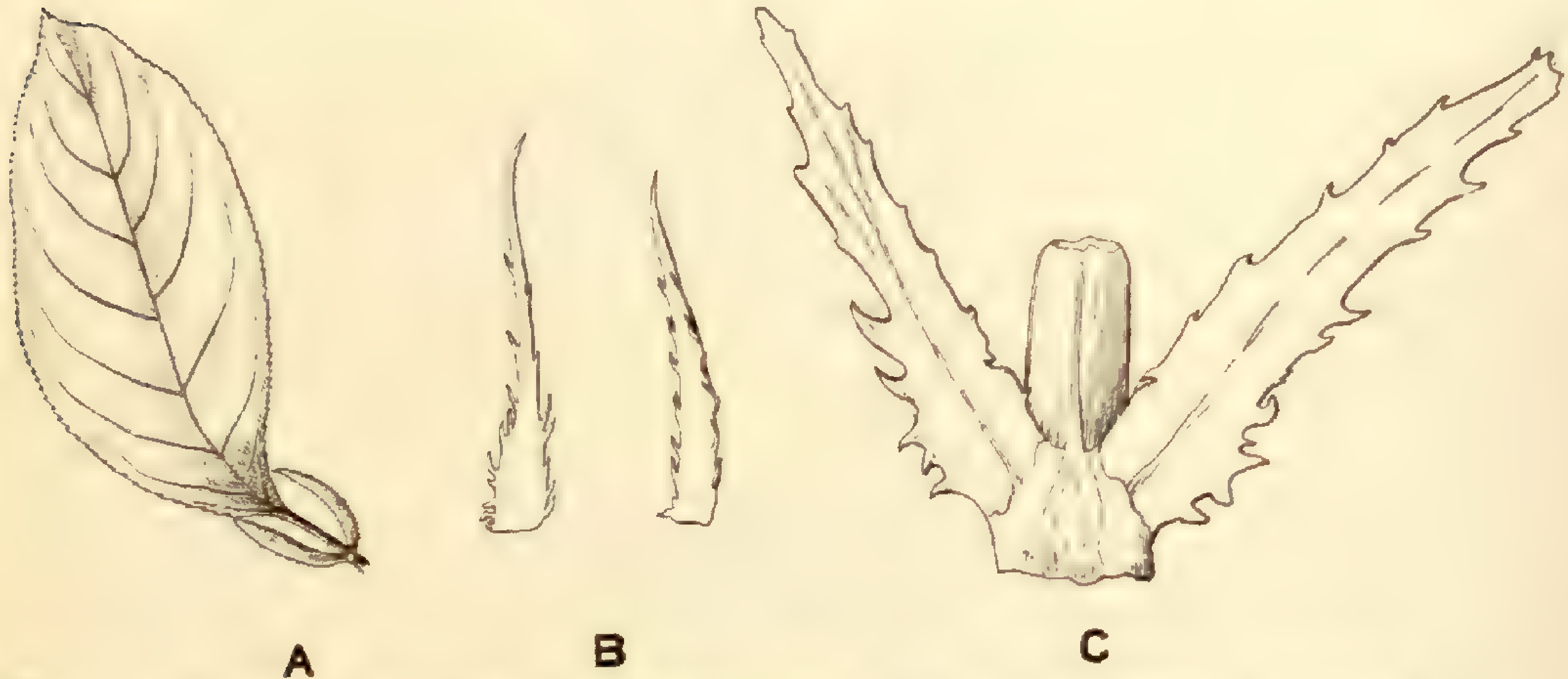

Fig. 1. *Prunus serotina.* A, normal leaf, × ½. B, normal stipules, × 3. C, leaf-base with enlarged stipules; the stump of the excised petiole is shown, × 3.

A small specimen of *Prunus serotina* growing near the propagating houses of the New York Botanical Garden was selected for the first test. All of the young unfolding leaves, except those of one basal branch, were dissected by the excision of the petiole near the stipules on April 24, 1903. None of the leaves had unfolded on the above date. The plant was visited daily and the successive leaves removed in the same manner leaving the stipules intact. A number of the other small trees of the same species growing near by were also available for comparison. The earlier part of the season was one of extreme drought. During the period of fifty-two days between April 16, a week before the beginning of the test, a total precipitation of only 1 cm. was recorded. It was noted that the scales and stipules were of longer duration and presented the appearance of increased superficial extension upon the delaminated branches within a fortnight after beginning the tests. The development of leaves and buds appeared to have almost ceased and an anatomical examination was made June 3–10 with the following results :

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* Goebel. Regeneration in Plants. Bull. Torrey Club, 30: 197–205. 1903.

The greatest length made by branches which had been defoliated from the beginning was 18 cm., while a length of 25 and 30 cm. was found in normal branches ; 18–20 leaves had been formed on defoliated branches and but 14 or 15 on normal ones. The basal internodes of the twigs showed but little difference in length in the two instances, being as much as 2 cm., although less in some cases. The internodes formed later in the season on the normal twigs attained a length of as much as 3.5 cm. in some instances, while those of the defoliated twigs varied from 1.5 cm. to one third that length. Consequently the defoliated twigs were closely crowded at the terminal part with scales and stipules. This crowding effect was accentuated by the fact that one or two small leaves were thrust out of the axillary buds, although no general activity of the bud was exhibited. In contrast with the behavior of *Acer*, it could not be made out that any extra number of lateral buds on the older parts of the branches below had been induced to awaken.

The correlative alterations in the stipules were very marked and consisted in changes in form, size, position, structure and period of endurance. Normal stipules of the cherry are thin-membranaceous, and generally of a reddish tinge containing almost no chlorophyl. These stipules are usually short-lived and fall off in such manner that on the above date they could be found only on two or three leaves on the terminal portions of twigs. The stipules on twigs on which the leaves had been dissected were both broader and longer, offering a superficial expansion of about five times the normal (see *f. 1*). The maximum measurements were but little greater than those of normal stipules formed earlier on the first internode, but their length, width and thickness was such as to give the exaggerated extension noted above when compared to correspondent structures on normal branches. Furthermore, three pairs of stipules were present on normal twigs and ten pairs on those which had been defoliated. It is thus to be seen that twigs which had been deprived of the laminar portions of the leaves made such development and retention of the stipules that they were able to expose about fifteen or sixteen times as much stipular surface as normal correspondent branches.

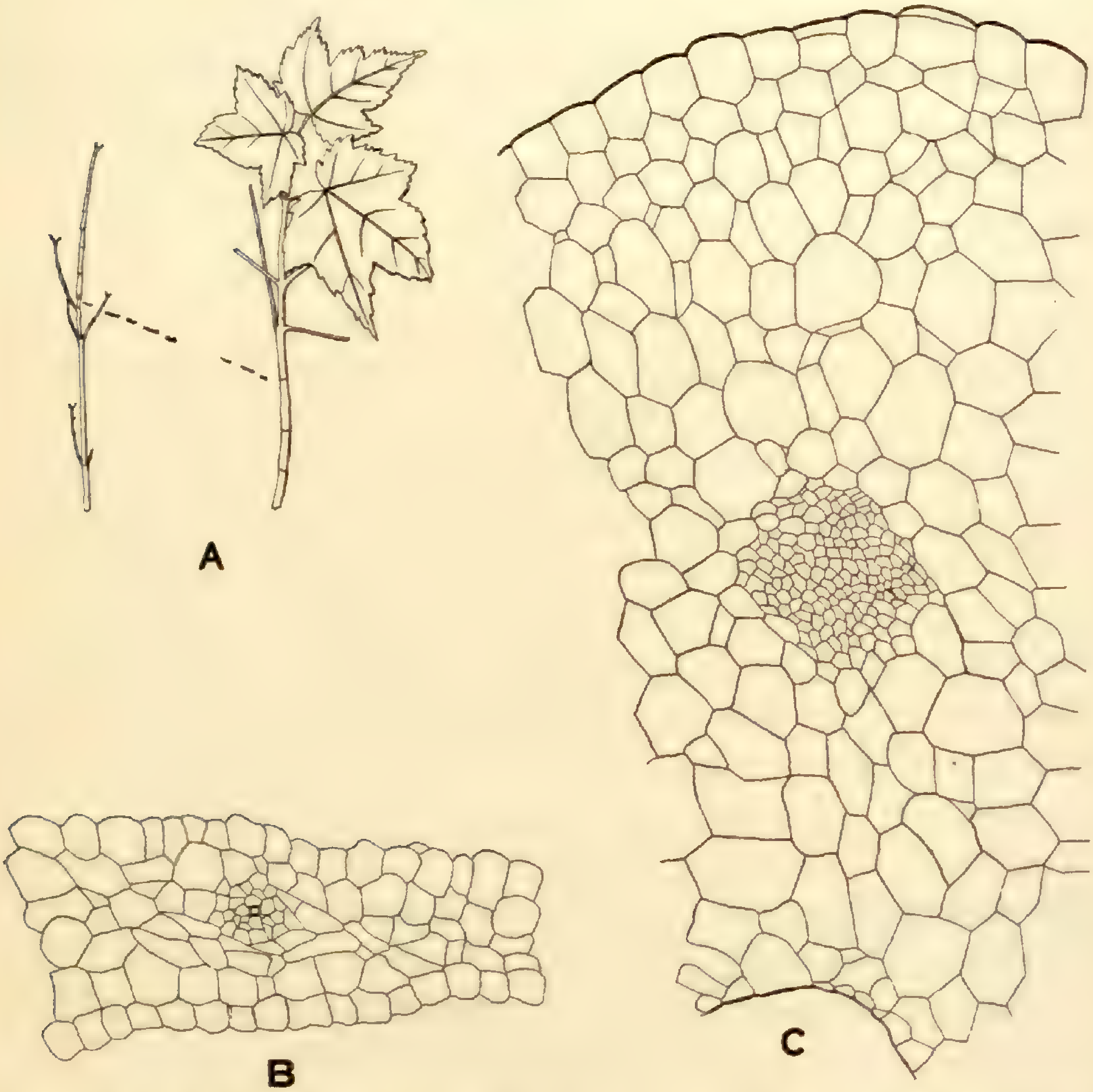

Fig. 2. A, *Acer;* normal and defoliated branches. The dotted line shows the bases of new growth. B, *Prunus;* transverse section of normal stipule. C, *Prunus;* transverse section of stipule of delaminated leaf. B and C are drawn to same scale.

The increase of the stipular surface consequent upon the removal of the laminae is not unknown, and Goebel notes that similar reactions are shown by the elder (*Sambucus nigra*).* He also found that the stipules of *Vicia Faba* were increased in superficial extension two to six times beyond the normal by the excision of the laminae in an early stage of development, and a similar exaggeration in the stipules of *Lathyrus Aphaca* resulted from the cessation of elongation or extension of the shoots. This correlation is not present in all plants, however, and not even in all Papilionaceae, since it was seen that the excision of the laminae of *Phaseolus multiflorus* had but little effect upon the size and structure of the laminae.†

The excision of the leaves of *Aristolochia*, in the course of the present experiments, did not cause any notable increase in size of the stipules as seen by general inspection, although no examination of the internal structure was made.

Kronfeld made a series of experimental tests of this matter in 1886, and found that the stipules of *Pyrethrum Indicum*, *Rosa semperflorens*, *Rubus fruticosus*, *R. Idaeus*, *Sida Napaea*, *Trifolium filiforme* and *Urtica urens* were not sensibly increased in size by the destruction of the laminae. The destruction of the laminae of *Pyrus Malus* was followed by an increase of the superficial expansion of the stipules amounting to a hundred per cent. The excision of the laminae of *Pisum sativum* was followed by an increase of the size of the stipules amounting to from fifty to one hundred per cent., while the excision of the stipules alone seemed to have the effect of causing earlier flower-formation. ‡

Stomata were found on both normal and abnormal stipules in *Prunus* in my own experiments. No examination of the number of stomata on the adjoining surfaces of the stem were made, but Braun has found that defoliation causes the formation of an increased number of these organs. § The enlargement of the stimulated stipules of *Prunus* had apparently not been accompanied by a multiplication of the epidermal cells, since these elements were both larger and wider in surface view than the normal.

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* Goebel. Organography of Plants, 1 : 210. 1900.

† Goebel. (Beiträge zur Morphologie und Physiologie des Blattes.) Bot. Zeitung, 38 : 836–837. 1880.

‡ Kronfeld, M. Ueber die "Correlation des Wachstums." Bot. Zeitung, 44 : 846–849. 1886.

§ Braun, K. Ueber Veränderungen im Gewebe entlaubter Stengel und Zweige. (Inaug. Diss.) Erlangen. 1899.

The enlarged stipules exhibited a thickness four or five times as great as the normal, chiefly due to increase in tissues and differentiations toward the structure of a typical lamina. A median layer of loosely arranged parenchymatous tissue contained much chlorophyl which was almost wholly lacking from the normal organ. This mesophyllary tissue also exhibited numerous intercellular spaces, and was altogether well adapted to carrying on photosynthetic and transpiratory functions.

The entire stipule, which is usually closely appressed to the petiole, was held at a more widely divergent angle than the normal. These adaptations have greater significance when it is understood that the total amount of stipular surface presented by a delaminated branch would amount to about fifteen or sixteen times as much as the normal. This comparatively normal increase, however, does not result in developing a foliar surface of more than one or two per cent. of that of the normal leafy branch.

Sections of the sixth internode from the base of the twigs formed in 1903 were examined in order to ascertain the effect of deprivation of the laminar structures and their partial replacement by the stipules. It has already been pointed out that the branches which had been delaminated had developed more internodes, the total lengths of which were less than of twigs normally grown, and had the appearance of being slightly thicker, but no measurements were made which might form the basis of an exact comparison. The epidermal tissues of the treated branch had greater radial and tangential diameters, and the underlying collenchymatous layers were but slightly thickened. The medio-cortex contained much more chlorophyl than the normal. The bast fibers were not so heavily thickened as in the normal, and the walls of all the internal tissues exhibited a slight yellowish tinge. The cambium showed a greater number of layers than the normal. The xylem was irregularly developed and seemed to have attained a less advanced stage of differentiation in its various elements than in the normal. The tangential development was notably deficient and the separate bundles were separated by wide rays of pith.

On June 15 the delaminated branches had assumed the appearance of a resting stage. The formation of leaves had ceased, and nearly all of the stipules had fallen off. The buds in the axils of the newly formed branches were enclosed and in the winter condition. My absence from the Garden during July prevented observations being taken during a period of four weeks, but an examination of the plants on July 30 showed that all of the newly formed delaminated branches of this season had perished and that buds on the older branches had awakened and extended to a length something less than the normal growth of the earlier part of the season.

The increase in the amount of chlorophyl in the cortex may be considered as a further effort to meet the losses ensuing from the lack of the laminar portions of leaves. The non-development of the phellogen and the imperfect construction of the bast fibers and fibrovascular bundles may be ascribed in part to a lack of formative material and in part to the absence of the stimulation ensuing from the decreased transpiration stream and the material usually formed in the laminae. In addition, the mechanical strains and stresses exerted by the foliar organs undoubtedly exert some stimulative effect on the rigidity and pliability of the stems by the induction of the development of various mechanical elements. The absence of stimuli of this character would account in part for the imperfect development of the stems.

The tests with *Acer* were much more restricted. The petioles were excised near the base and the effect upon the activity of the vegetative points noted. Only a single basal branch of a small tree was treated in this manner, and comparisons were made with corresponding portions of similar branches arising from the same part of the central stem.

The single normal branch taken for comparison developed four internodes which had a diameter about thirty per cent. greater than the internodes of the defoliated branch. The total length of the four newly formed internodes amounted to 78 mm., the longest being the third from the base of the yearly growth, measuring 25 mm. Eight active functional leaves were developed. (One has been cut away in the illustration, *f. 2, A.*) The newly-grown part of the defoliated branch measured 48 mm. and comprised seven internodes, the longest of which was the sixth from the base, measuring 8 mm. The excision of the leaves had induced the development of one bud in the axil of the last internode of the previous season. The branchlet thus formed showed two long internodes, the basal one of which measured 14 mm. Two branchlets were produced at the next node below on the newly-formed portion of the main branch, which showed two and three internodes and were 10 and 15 mm. long respectively. The third internode below produced two branchlets 6 and 12 mm. long and composed of two internodes.

The lateral branchlets of the main branch showed less total growth and also less marked development of the lateral buds correspondent to the general habit of the normal. Activity of the vegetative points on the defoliated and normal branches had practically ceased on June 15, the mutilated branch showing no prolongation of the period. The departures from the normal structure of the stem were fairly similar to those described in *Prunus*. Chlorophyl was quite as profusely developed in the normal as in the treated branch, however, and was found in the medullary rays in great abundance.

The above results are found to agree in the main with those of Boirivant, who practiced defoliation and delamination and noted the effect upon stems and upon petioles of *Faba vulgaris*, *Sarothamnus scoparius*, *Genista tinctoria*, *Lathyrus odoratus*, *Chenopodium album*, *Atriplex nitens*, *Linum usitatissimum*, *Galium Cruciata*, *Asparagus officinalis*, *Robinia Pseudacacia*, *Arachis hypogaea* and *Ailantus glandulosa*.* It is to be noted, however, that the epidermal tissues in my material showed enlargement in the tangential axis, and one or two other minor differences appear. Boirivant's studies included a consideration of the anatomy of the petioles of leaves of which the laminae had been cut away, and in these organs he found an exaggerated production of chlorophyl, modifications of the cortical tissues consisting of added differentiations of palisade tissue, and enlargement of the vessels and more lignification of the tracheids and pith. I am not able to find that he noted the effects of the treatment upon the stipels of *Robinia*, or made observations upon the reaction of the hypopodium especially.

The observations of Braun also extend over the matter of the effect of delamination on stems. His observations included

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* Boirivant, A. Recherches sur les organes de remplacement chez les plantes. Ann. Sci. Nat. Bot. VIII. **6**: 309–400. 1897.

Lamium Orvala, *Aconitum Stoerkianum*, *Clematis Vitalba*, *Syringa vulgaris*, *Corylus Avellana atropurpurea*, *Gillenia trifoliata*, *Prunus Mahaleb*, *Aesculus Hippocastanum*, *Ampelopsis hederacea*, *Aristolochia Sipho*, *Acer platanoides*, *Rosa centifolia* and *Phaseolus multiflorus*.* In addition to results previously cited, Braun concludes also that the effect of delamination is to increase the photosynthetic capacity of stems, retard the development of internodes and interrupt the formation of woody tissue, all of which is confirmed by my own results. Braun also suggests that the condition of delaminated stems may be regarded as pathological, and that it is directly due to mechanical interferences with the functions involved. The condition of delaminated branches is undoubtedly one of hypoplasia, but a careful consideration of the various features involved leaves but little doubt that the failure to develop is largely due to the absence of the customary stimuli in response to which the several tissues carry on growth and differentiation in a normal manner. The results in question are quite as much a matter of correlation dependent upon stimulative factors, as the variations in position and growth in compound leaves as discovered by Zeleny.

The more important facts observed as a result of cutting away the laminae of the leaves of *Acer* and *Prunus* by severing the petiole near the base may be briefly summarized as follows:

I. The duration of the stipules of *Prunus* is increased, so that ten pairs of these organs are to be found on branches at a time when only two or three pairs are present on a normal branch.

II. The stipular surfaces exposed on delaminated branches of *Prunus* were sixteen times as great as on normal branches.

III. The individual stipules of *Prunus* were of a maximum measurement in length and width on the delaminated branches and were much larger than the stipules present on the corresponding part of normal branches.

IV. The position of the stipules of *Prunus* on delaminated leaves was more divergent than the normal, and approximated that of a typical leaf.

V. The structure of the stipules of *Prunus* was modified in such manner as vastly to increase their capacity for photosynthesis and transpiration.

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* Braun, A. Ueber Veränderungen im Gewebe entlaubter Stengel und Zweige. (Inaug. Diss.) Erlangen. 1899.

VI. The loss of the lamina acts as a stimulus which induces a development and differentiation of spongy parenchymatous and other tissues in the stipule, and the formation of chlorophyl.

VII. The lateral buds of *Acer* on internodes formed during the previous season were awakened by defoliation of the extending apical portion.

VIII. The period of activity of the vegetative point of the terminal portion of a woody branch is not lengthened as a result of defoliation.

IX. The total length of the newly formed portion of the branches defoliated during growth was thirty to sixty per cent. less than that of normal branches occupying the same relative positions on the shoot.

X. The number of internodes developed on defoliated branches was greater than in the normal.

XI. The defoliated internodes were of a diameter not greater, sometimes less than the normal, and had accomplished less perfect differentiation.

XII. Branches compelled to accomplish growth in a defoliated condition generally are found to be in a state of hypoplasia, the undeveloped and imperfectly differentiated condition of the tissues being due to the lack of correlative stimuli.

New York Botanical Garden.

Desmids from Bronx Park, New York

By Joseph A. Cushman

The following species were identified in a small collection made by Mr. Thomas Barbour in the latter part of April, 1903. The material was from a small pond in the New York Zoological Park, Bronx Park, New York City. *Closterium* was especially abundant and several other genera were represented.

1. *Closterium acuminatum* Kg.

Diam. 22 μ, length 185 μ. Abundant. (Herbarium of J. A. Cushman, No. 327.)

2. *Closterium Dianae* Ehrb.

Diam. 15 μ, length 215 μ. Common. (H. C., No. 328.)

3. *Closterium Delpontii* (Klebs) Wolle.

Diam. 32 μ, length 310 μ; another specimen measured, diam. 33 μ, length 360 μ. Occasional. (H. C., No. 330.)

4. *Closterium Jenneri* Ralfs.

Diam. 15 μ, length across ends 65 μ. Frequent. (H. C., No. 327.)

5. *Closterium lanceolatum* Kg.

Diam. 40 μ, length 315 μ. Rare. (H. C., No. 329.)

6. *Closterium Leibleinii curtum* West.

Diam. 33 μ, length 185 μ; another specimen very similar in all but size measured, diam. 52 μ, length 275 μ. (H. C., No. 327.)

7. *Closterium striolatum* Ehrb.

Diam. 35 μ, length 425 μ. Common. (H. C., No. 333.)

8. *Docidium Archerii* Delp.

Diam. 48 μ, length 560 μ; another specimen diam. 48 μ, length 325 μ. Frequent. (H. C., No. 327.)

9. *Docidium Trabecula* (Ehrb.) Naeg.

Diam. 38 μ, length 275 μ. (H. C., No. 331.) Another specimen, diam. 31 μ, length 320 μ. (H. C., No. 327.)

10. *Docidium* sp. ?

Diam. 35 μ, length 630 μ. (H. C., No. 329.) Frequent. Contents appear granulate, almost netted, 12–15 dark spots scattered through each semi-cell.

11. *Penium margaritaceum* Breb.

Diam. 30 μ, length 190 μ; another specimen, diam. 25 μ, length 230 μ. Common. (H. C., No. 327, 330, etc.)

12. *Cosmarium granatum* Breb.

Diam. 32 μ, length 40 μ. Occasional. (H. C., No. 332.)

13. *Cosmarium laeve* Rab.

Diam. 14 μ, length 20 μ, isthmus 4 μ. Occasional. (H. C., No. 328.)

14. *Cosmarium laeve septentrionale* Wille.

Diam. 10 μ, length 14 μ, isth. 3.5 μ. Smaller than the measurements given by Wolle. Specimen like *pl. 43, f. 14*, Wolle, 1892. Occasional. (H. C., No. 328.)

15. *Cosmarium ovale* Ralfs.

Diam. 75 μ, length 95 μ, isth. 19 μ. Common. (H. C., No. 330.)

16. *Euastrum pingue* Elf.

Diam. 33 μ, length 38 μ, isth. 9 μ. Crenations almost approach the appearance of granules on the edge of one of the semi-cells. Occasional. (H. C., No. 330.)

17. *Staurastrum crenulatum* (Delp.) Naeg.

Diam. 35 μ; one semi-cell triangular in end view, the other 5-rayed. It is more like this species than any other, although the end of the triangular semi-cell greatly resembles *S. polymorphum.* (H. C., No. 328.)

18. *Staurastrum muticum* Breb.

Diam. 44 μ. Common. (H. C., No. 332.)

19. *Staurastrum orbiculare* (Ehrb.) Ralfs.

Diam. 45 μ, length 50 μ, isth. 15 μ. Common. (H. C., No 328.)

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June, 1903.

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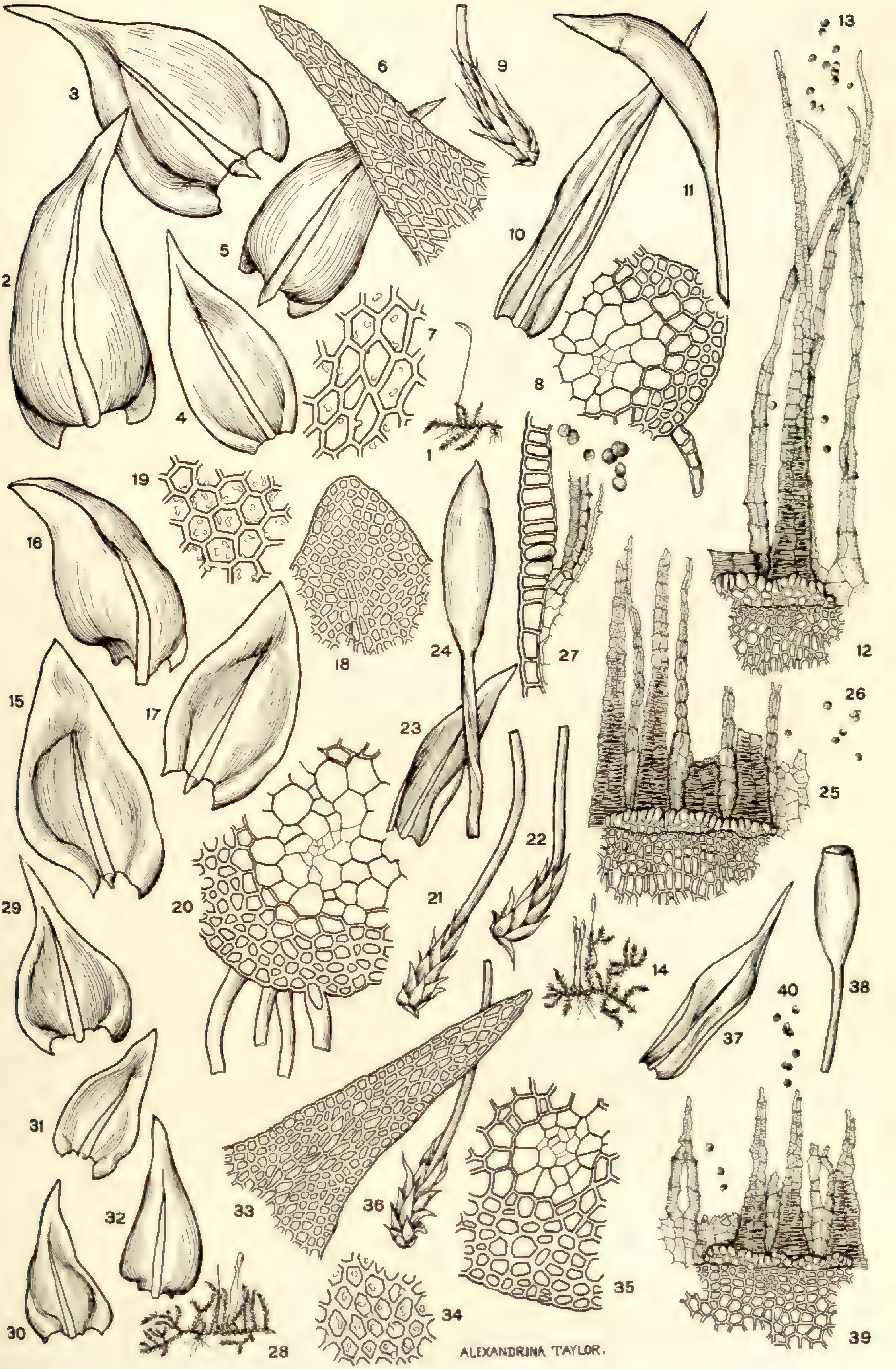
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ALEXANDRINA TAYLOR.

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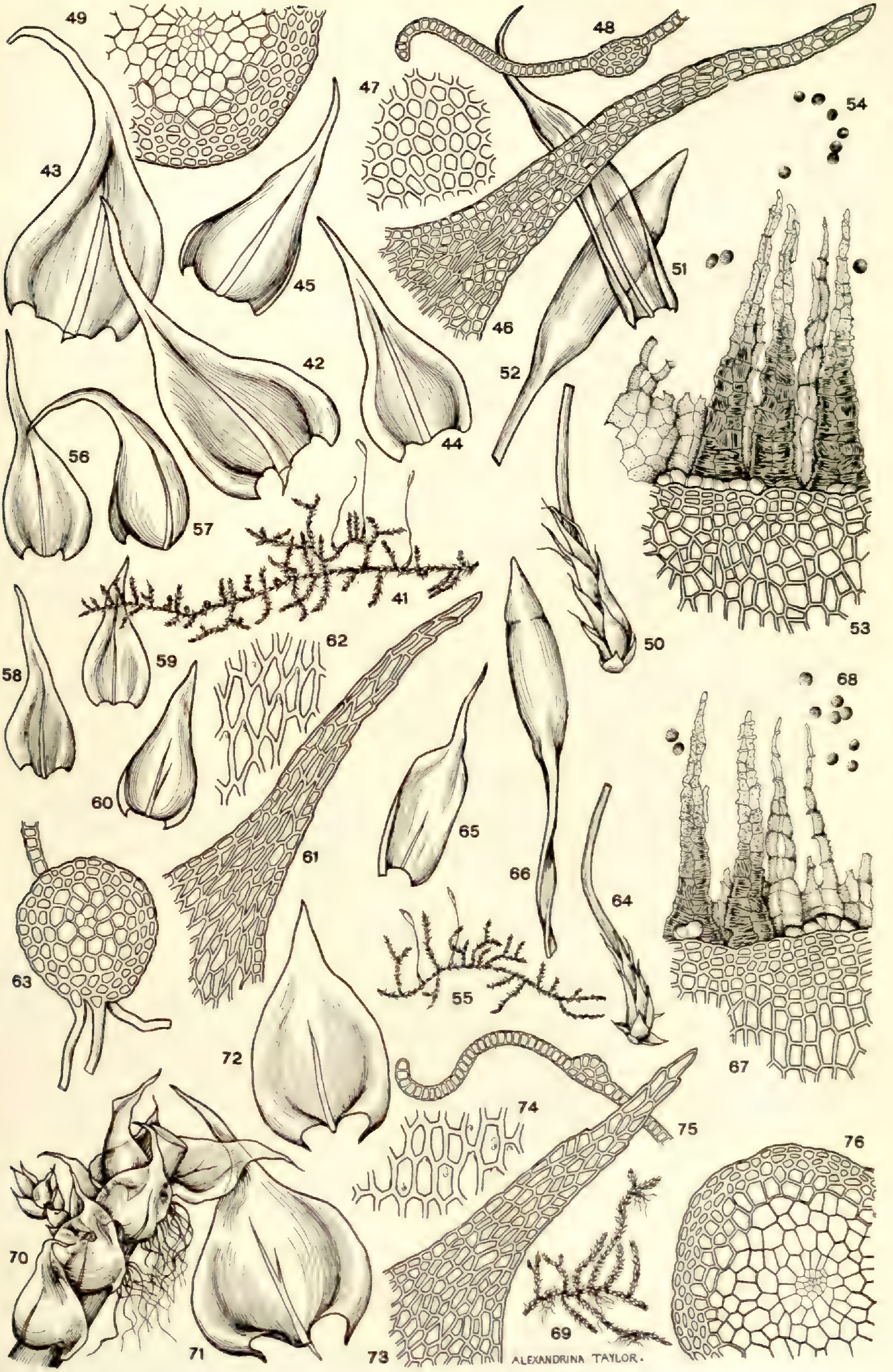
1–13. L. ARENICOLA. 14–27. L. OBSCURA. 28–40. L. MICROCARPA.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BULLETIN

OF THE

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OCTOBER, 1903

Studies in Plant Hybrids: The Spermatogenesis of Hybrid Peas*

BY WILLIAM AUSTIN CANNON

(WITH PLATES 17–19)

Up to the present the studies on the origin and development of the spores and sex-cells of hybrids have been made with no definite knowledge of the manner of the variation of the hybrid race and without regard to or accurate knowledge of the degree of fertility or sterility of the forms, and it seems almost unnecessary to remark that no study can be at all complete, whatever its results or conclusions may be, that does not take into consideration each of these conditions.

Studies on the sporogenesis and spermatogenesis of hybrids include the researches on cannas by Guyer,† on cotton by Cannon, on *Drosera* by Rosenberg, on *Gladiolus* by Metcalf, on pigeons by Guyer and on *Syringa* by Juel. Nothing definite is known, so far as I am aware, about the variation of any of these hybrids, and as regards their fertility probably not one is entirely fertile, and *Syringa* at least is thought to be quite sterile.

There are two or three conditions at least to which a hybrid plant should conform in order to be well adapted for study from a morphological standpoint. These are briefly: the hybrid must be fertile; it must vary in a definite and known manner; and, finally, it must be suitable in itself, as distinguished from all other requirements, for histological study.

One reason why the pea hybrids are so well adapted to experimental researches is that they are fertile. This, indeed, was one of the reasons that led Mendel to select them for his studies. I

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* This study was made with the aid of Grant No. 27 of the Carnegie Institution.

† See bibliography at the end of this paper.

[The preceding number of the BULLETIN, Vol. 30, No. 9, for September, 1903 (**30**: 463–518, *pl. 15, 16*), was issued 3 S 1903.]

have observed also that the peas used in the present study were fertile; they produced pods which were usually well filled with seeds capable of germination. These observations are in harmony with the manner of the formation of the spores; no irregularities whatever, which in any way were traceable to the plants as hybrid organisms, were seen. If these observations are correct, the conclusion can hardly be avoided that the variations and reversions of hybrid peas are associated with normal processes, such as are found in the pure types, and hence that abnormalities are merely indications of the hybrid nature of the forms that bear them, although by no means diagnostic characters. It is then a question fairly open for the cytologist to determine, what the nature of those processes are, and this has yet to be done.

The hybrids used in this study,* Fillbasket × Debarbieux and Express × Serpette, showed variation after the law of Mendel, although I should state that they were not examined more than was necessary to surely establish this point. The seeds from which the plants studied were derived were from those of the first generation. The Fillbasket × Debarbieux seeds were yellow and green, nearly in the ratio 3:1. Of course most of the flower-buds were removed for study, but in a few cases I left the flowers to fertilize themselves. The plants which came from the green seeds bore green seeds only, and those from the yellow seeds bore seeds that were both yellow and green in the ratio 3:1. In the crosses in which Serpette was used as one of the parents, as for example Express × Serpette, the Serpette dwarf character was noticed in the offspring as presumably the recessive one; it appeared in at least one third to one half the total number of third-generation plants. In Express × Serpette there were seventy-two plants which resembled the Express ancestor, and thirty which were dwarfed and which were like the Serpette race. The illustrations (*f. 34–37*) show fairly well the appearance of these reversionary types and the pure forms also.

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*I am indebted to Professor William Bateson for the seed from which the hybrids were raised. Professor Bateson very generously sent me some first crosses, several of the second generation and also the pure types.

I wish also to acknowledge the assistance of Mr. Homer D. House, of Columbia University, for aid in preparing material for study, and that of Miss Palmyre de C. Clarke, of the New York Botanical Garden, who prepared the bibliography.

FILLBASKET AND DEBARBIEUX, PURE RACES

No difference in the origin and development of the microspore was noted between the pure races Fillbasket and Debarbieux. In both the reduced number of chromosomes was seen to be the same, namely seven, and the chromosomes appeared to be quite alike in each ; to avoid repetition the general account of the maturation processes will be deferred until the next topic. Favorable material, however, gave opportunity to observe the sporogenous divisions in Fillbasket and the results are here presented.

In the most of the sporogenous divisions the mitotic figures are likely the same as in the somatic nuclei ; but in late anaphases or early telophases certain characters were seen which were apparently somewhat different. In early telophase of one of the later sporogenous divisions the chromosomes are associated in pairs, touching by one, the polar, end. A nucleus with such chromosomes is shown in *f. 4*. This division was evidently the last sporogenous one, that is, the nucleus figured would become that of the spore mother-cell without further division. Whether the chromosomes are ever in touch throughout their whole length, as appears to occur in Fillbasket × Debarbieux (*f. 6*), was not determined. The later history of the chromosomes is of great interest, since upon a proper understanding of it may depend an appreciation of the significance of the loops of chromatin which appear subsequently in the nucleus as one of the prophases of the first maturation division. If, as supposed, the spireme of the nucleus of the spore mother-cell is double, we might look for a previous doubling of the chromosomes, although this might perhaps not follow. I have seen no clear indication that the chromosomes form a double spireme in the telophases of the last sporogenous division. The behavior of the chromosomes at this time is as follows : As they approach the poles of the spindle they are appreciably more uniformly arranged and more nearly parallel to the long diameter of the spindle than in the other divisions in the sporogenous cells, when at the poles the chromosomes unite or touch two and two by the polar ends. In this condition they enter the resting stage ; a continuous spireme was not seen. In some nuclei the adjoining pairs of chromosomes were apparently united by their free ends, but I did not surely determine this point. If the chromosome pairs are united in this manner a continuous spireme of single chromosomes united end to end would be the result. The results of my observations upon this point were somewhat contradictory, and this may have been owing to the possibility that not all of the nuclei studied were undergoing the last sporogenous division, and that the pairing of the chromosomes and the form of telophase following are, in the pea, peculiar to the presynaptic nuclear division. I hope at another time to give a more complete account of this division.

When I observed the association of chromosomes as above described I supposed that it was merely from chance, which indeed may yet prove to be the case, and not the usual and normal occurrence in such cells, because it surely is not at all likely that so noticeable a thing could for any length of time escape the eyes of trained cytologists. The better to reinforce the correctness of my observation, or to prove it false as the case might be, I studied the mitoses in the nuclei of somatic cells. As a rule, there is no indication whatever in the somatic nuclei of peas of the association of the chromosomes in twos, but in one nucleus an appearance recalling the pairing was observed. In this case a closer examination showed that the association did not include all of the chromosomes and was very evidently one of chance merely; so that it seems to me that the association of the chromosomes in pairs in the last sporogenous division in Fillbasket does not find a counterpart in any somatic cells and is not the result of chance.

FILLBASKET × DEBARBIEUX

In studying the sporogeny of the hybrid Fillbasket × Debarbieux my aim has been rather to notice departures from the "normal," and by it to discover if possible the structural causes of the remarkable "splitting" of the Mendelian hybrids, than to examine critically and minutely the several nuclear divisions for themselves. Accordingly I have observed the behavior of the chromosomes more especially in the two maturation mitoses, in the first division of the microspore and in the last division of the sporogenous cells.

The sporogenous cells of the hybrids were rather easily distinguished even in young anthers because of their position and by the greater density of the cytoplasm, although it should be said that it is not seldom difficult surely to determine the character of a given cell. To study the divisions from which the sporiferous tissue arises it is necessary to obtain very young anthers indeed, those which are merely slight protuberances on the primordium of the flower. The difficulties in the way of studying the anther are decidedly increased from the fact that the inflorescence consists of not more than four or five flowers, all usually in widely different stages of development.

For the most part the nuclear divisions in the sporogenous cells of Fillbasket × Debarbieux are of the regular equational type, quite the same as those in the somatic cells of the plant. That is, fourteen segments are formed in the prophases and these become arranged in the equatorial plate and in metaphase are already split before the migration to the poles of the spindle. In anaphases the chromosomes are frequently L-shaped, although not so sharply bent, and are arranged haphazard, that is, as purely by chance. In the telophases the chromosomes unite end to end and form a spireme; this becomes changed into a delicate reticulum in which all trace of the chromosomes as such disappears.

In some of the later sporogenous divisions a departure from the usual appearance was noted as in the case of the pure form Fillbasket. In Fillbasket × Debarbieux the same curious association of chromosomes two and two was observed in a few cases. *F. 6* shows an anaphase of the last sporogenous division; the pairing was even more clearly marked in the preparation than in the sketch. The pairing was with a single exception observed in anaphase or early telophase only. The exception is shown by *f. 5*, which is an equatorial plate in probably the last division before synapsis. I have not seen the association in early anaphase for the reason perhaps that the chromosomes are at that time under the influence of the spindle fibers.

When the chromosomes reach the poles of the spindle they unite by their polar ends, and these appear to fuse together, making a more or less well-marked ring from which depend the chromosomes in pairs. This is shown very imperfectly by *f. 7, 8* and *9*. In no case did I see a spireme which I could surely say was continuous or which was made up of more than two elements; this may well be because the particular stage was wanting in the preparation. On the other hand instances were observed, like *f. 8*, in which a reticulum was being formed from the condition as just described. The exact fate of the chromatin was thus not determined.

The association of chromosomes in pairs in the early history of the reproductive cells recalls the similar condition in animals as given by Montgomery * and Sutton.† But the significance of the association in hybrids is not entirely clear, since with Montgomery's hypothesis in mind that in pure races the two chromosomes of each pair are of different parentage, it seems difficult to conceive of Sutton's as applied to hybrids, that the members of each pair cover the same field of development; because in hybrids the latter can only be true in a broad way, depending apparently upon the affinities of the pure parents of the form. It may be, however, that the differences between the chromosomes of any pair in hybrids capable of forming functional spores are so slight that union is possible even if the potentials of the chromosomes are not identical.

After the sporogenous cells are cut off there ensues a long period of growth during which the nucleus of the young spore mother-cell undergoes characteristic changes. The chromatin of the nuclear reticulum becomes gathered to one side of the nucleus and the contracted condition known as synapsis results. The preparation for synapsis takes place at an early time in the history of the spore mother-cell, and the portions of the nuclear changes resulting in synapsis which were seen may be briefly described. The delicate reticulum which extends through the nuclear vacuole of the resting nucleus becomes so changed that small masses of chromatin of unequal form and size are found scattered along its meshes, more especially in the peripheral part of the nucleus. These masses are arranged in lines which often radiate from the nucleolus as a center; the linin threads which connect the masses may be seen for a considerable distance from them extending into the nuclear vacuole. From a position extending over the entire periphery of the nucleus the chromatin becomes gathered to one side of the vacuole; when it enters into the synapsis stage it is probably already in the form of a continuous spireme. It is much bent with short turns and appears usually to be homogeneous and not split; the spireme at this time closely resembles the much convoluted thread with its short, sharp turns as it emerges from the synapsis stage. Since the chromatin assembles in a spireme before the so-called synapsis condition the significance of the latter is not apparent in these forms.

---

* Montgomery, T. H. The heterotypic maturation mitosis in Amphibia and its general significance. Biol. Bull. 4: 259. 1903.

† Sutton, W. S. On the morphology of the chromosome group in *Brachystola magna*. Biol. Bull. 4: 24. 1902.

The cytoplasm of the spore mother-cell is reticular and it always, from the spore mother-cell to the tetrad, retains this structure. In this regard the pea is very different from the cotton hybrid in which kinoplasm forms a marked character of the cytoplasm in the more advanced stages of spore formation, and from some of the homologous cells of *Syringa Rothomagensis* * in which kinoplasm is strongly developed. The exaggerated development of kinoplasm or filar-plasm in the cytoplasm of the spore mother-cells is therefore not a constant or diagnostic feature of hybrids.

Although I did not study closely the origin of the achromatic figure, I observed that it is derived from a multipolar one. The multipolar spindle originates in groups of fibers which are placed near the outer edge of the cytoplasm and which radiate from a common point towards the nucleus. The place of genesis of the achromatic figure is therefore very different from that of the cotton hybrid, and the structural reason appears to lie in the presence in the latter, and absence in the former, of a dense perinuclear zone of cytoplasm. The achromatic figure in cotton originates inside of this perinuclear zone, which thus appears to inhibit its more peripheral origin. It may also be that the zone of denser cytoplasm which in the cotton closely surrounded the nucleus not only formed a limiting boundary for the spindle, but at the same time made necessary for the mechanical support of the cell the formation of an outer layer of kinoplasm, and that its absence in the pea not only changed the structural relations of the parts of the cell but altered the mechanical condition as well, making the formation of the kinoplasmic layer unnecessary.

The first maturation mitosis is heterotypic. The chromosomes in the metaphase are not different from those in the pure races Fillbasket and Debarbieux. Their relatively large size and small number make the observation of them comparatively easy and sure. The reduced number is seven; this number was repeatedly seen in the first division and was verified in the second mitosis and in that of the division of the nucleus of the tetrad also.

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* Juel, H. O. See bibliography.

The chromosomes in the anaphases of this division are more or less bent and some show the splitting sometimes seen in these stages of division. There was an equal apportionment of the chromosomes, both as regards their number and size, to the daughter nuclei. The single exception to this, and the only abnormality noticed in the hybrids, is shown in *f. 23*. In the nucleus from which the sketch was made one chromosome lagged behind its companions; fission, also, had not taken place.

The daughter nuclei undergo reconstruction to a greater degree than was observed in the cotton hybrid, but on account of the small size of the nuclei the study of them is difficult and unsatisfactory. The chromosomes in early telophase are much elongated and appear to unite end to end to form a single spireme, which later becomes lumpy and more or less reticular. The identity of the chromosomes is quite lost.

In the prophases of the second division a spireme, which does not seem to be split, may be seen, and the chromosomes formed from it become associated in pairs in the nuclear plate, but they may not on that account, as Mottier shows, be sister chromosomes. It is probable, however, that they are, and that they are not homologous with the pairs found in the presynaptic division. The metaphase or the anaphases present no noteworthy condition. The reduced number of chromosomes, seven, was frequently observed and the number verified.

In late anaphases of the second division the cell-plates separating the daughter nuclei may be seen, and when the granddaughter nuclei are reconstructed cell-division occurs. Immediately after the division of the cell the tetrads are angular in form, but they soon become spherical and at length they assume the elliptical form characteristic of the pollen-grain. During these changes in form the tetrad increases much in size and the nucleus of the young spore moves from its early central position to one end of the cell and there prepares for the division of the nucleus of the microspore.

The first division of the nucleus of the spore (*f. 32*) appears to be similar to that of the somatic nuclei except for the number of the chromosomes and the shape of the spindle. The chromosomes are of course the reduced number, and the spindle, owing perhaps to the eccentric position of the nucleus, is somewhat truncated. As in the two preceding divisions, the distribution of the chromosomes in this one was apparently perfectly equable. Therefore in all and in each of the nuclear divisions which were directly connected with the development of the microspores the number of the chromosomes, and also presumably the amount of chromatin, were equally distributed.

In late anaphase of the first division of the nucleus of the microspore a cell-plate is seen separating the crescentic-shaped generative nucleus from the vegetative one. Reconstruction of the two nuclei goes on at an unequal rate. The vegetative appears always to form its wall in advance of the sister nucleus, and its chromosomes are also the first to become reticulated and lose their identity. In the reconstruction of both nuclei excellent opportunity was given to observe the beginning and extension of the nuclear wall, which appear to occur precisely as Lawson has described.*

SERPETTE, PURE RACE.

The material of the pure parents of the Express × Serpette hybrid at my disposal was not sufficient to permit an extended study of either; but some observations were made on the critical stages of spore-formation in Serpette.

The first maturation division in Serpette is heterotypic and the second homotypic. In the anaphases of the first division the chromosomes were not seen to be split, either for part or all of their length, as was the case in the other pure races and the hybrids also. In the telophases of the daughter nuclei the chromosomes unite end to end and form a continuous daughter spireme. In both maturation mitoses the reduced number of chromosomes was seven. No differences in form or size were noticed between the chromosomes of this and those of the other pure races.

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* Lawson, A. A. On the relationship of the nuclear membrane to the protoplast. Bot. Gaz. 35: 305. 1903.

EXPRESS × SERPETTE

Like Fillbasket × Debarbieux, this is a second generation hybrid, and it also, as has been described in a preceding paragraph, shows the splitting into several types after the law of Mendel. The reversion of Express × Serpette as regards the quality of size and form of the plants is fairly well indicated by *f. 34–37*, where the pure parents are also represented. It should be noted that the sketches are drawings from photographs and that the plants were photographed at the same time and under precisely the same conditions, so that the figures faithfully reproduce the relative forms and sizes of all of the plants.

The sporogeny of Express × Serpette corresponds closely in the points examined to that of Fillbasket × Debarbieux, although in certain regards, which will be indicated, a difference between the two was noted. Also some phases of development were represented in my preparations of Express × Serpette, not found in those of the other hybrid, and these will be mentioned, in addition to the preceding, rather than a more complete account. By this method I shall avoid unnecessary duplication; the two hybrids are so nearly alike in the matter of spore origin and development that a description of these processes in the one would for the most part answer perfectly well for the other.

The series representing the nuclear divisions in young anthers was not so complete in Express × Serpette as in Fillbasket × Debarbieux, and possibly for this reason I have not so complete evidence of the association of the chromosomes in pairs in the last sporogenous division in the former as in the latter hybrid. It was observed, however. An apparently good example of the pairing was seen where perhaps one would not expect it, namely, in the division by which the sporangial wall is separated from the inner sporiferous tissue. The outer cell resulting from this division by further division gives rise to three series of cells, the inner of which forms the tapetum; the inner cell of the division noted becomes converted without further division into a spore mother-cell. The division referred to occurs rather late in the pea. Both of the nuclei resulting from this division had their chromosomes arranged in twos. If the curious association of the chromosomes is an especial preparation for synapsis, the condition of the outer one is surely paradoxical.

The nucleus of the spore mother-cell enters into a complete resting condition in which it remains during much or most of the period of growth of the cell. As a preparation for synapsis the chromatin of the recticulum collects into masses of irregular shape and size, more or less arranged in threads, about the periphery of the nuclear vacuole. The chromatin-thread at length takes up a position around or closely applied to the nucleolus and the synapsis stage results. When the mass of chromatin unloosens, it is seen to be made up of a much bent ribbon. The spireme is at first beaded in appearance, but it becomes more regular in outline and also increases in its capacity for absorbing stains. The splitting of the spireme was not clearly seen, although evidences of it were noticed. In a few cells I saw the chromatin-loops which are characteristic of the prophases of the first maturation mitosis (*f. 15–17*), but in each case the loop was not contracted and did not show the second fission which was observed in the cotton hybrid.

The two maturation divisions were quite like those seen in Serpette and in Fillbasket × Debarbieux. The reduced number of chromosomes was seven.

A difference in the origin of the multipolar spindle of the first mitosis of Express × Serpette from that of Fillbasket × Debarbieux was noted (this stage was not seen in Serpette), but whether it was an artefact or not I was unable, because of the lack of material, definitely to determine. In several spore mother-cells the cytoplasm was very dense in the immediate neighborhood of the nucleus, forming what was in effect a perinuclear zone. In these cells the multipolar spindle seemed to have its origin wholly within the nucleus. The linin became lumpy and very distinct, it formed a mesh-work which gave the appearance of polarity, and had every indication of being the genesis of the multipolar spindle. The nuclear wall remained in some cases recognizable even when the intranuclear material was of a pronounced fibrous character. The departure from the extranuclear origin of the spindle observed in Fillbasket × Debarbieux is certainly a marked one, and interesting even if it proves in the end to be an artefact.

SUMMARY

The main points in this paper may be briefly stated as follows :

1. Both of the hybrids studied and reported on in this paper, Fillbasket × Debarbieux and Express × Serpette, were of the second generation, that is, their grandparents were pure races of peas ; both of the hybrids exhibited variation after the Mendelian law.

2. The hybrids are fertile.

3. Both of the hybrids matured their spores quite as the pure ancestral forms did. The first maturation mitosis was heterotypic, the second homotypic.

4. The reduced number of chromosomes is seven, the somatic number fourteen.

5. No abnormal mitoses were observed.

6. In the anaphases of the last sporogenous division of both hybrids, and of the pure form Fillbasket, the chromosomes were associated in pairs ; this condition was seen also in one nucleus of Fillbasket × Debarbieux that was in the nuclear plate stage. The paired condition is probably not the result of chance ; further work, however, which the writer hopes to carry on, will be necessary definitely to determine this point.

CONCLUSIONS

If the physical basis for the Mendelian variation of hybrid peas was not demonstrated by a single histological study of them, certain conclusions which touch more or less directly the causes of the variation may nevertheless be legitimately although tentatively drawn. In the first place it has been shown that the variation of the peas, in the third generation at least, is due entirely to the union of gametes which originate and develop quite the same as do those of the pure ancestral types, or in other words, abnormalties and irregularities of nuclear divisions do not form the basis for the variation of these hybrids.

What then is the probable structural basis for the Mendelian variation of the hybrid peas ? As has already been intimated, I think it is fairly well shown that this basis is the same as that of the variations in the pure forms, and if so an understanding of the latter should give the key to explain the former as well. But nothing is clearer than the fact that the present conception of the essential nature of the maturation processes in pure races of plants does not provide adequate grounds for this variation. This study will hardly profess to do this, but I may repeat what I have before suggested * and what Montgomery † and Sutton ‡ have emphasized, that a study of the early history of the reproductive cells may give some clue leading to a better understanding of the meaning of heterokinesis, and, at the same time, a truer conception of the physical basis for variations, both in pure races and in hybrids. With this idea in mind I have studied, as well as the material at hand would permit, the divisions of the sporogenous cells, more especially the last one, the division preceding the first maturation mitosis, in the hybrids and in the pure form Fillbasket, and I have found unmistakable evidence of an association of the chromosomes two and two. Of course I cannot say positively that this was not a chance association, since I could not trace the later phases of these divisions as closely as would have been desirable, but the pairing was observed in well prepared material and had every appearance of being the normal and regular occurrence. If further studies confirm this observation, it may prove of great importance in explaining the structure of the heterotype rings. There are difficulties in the way of positively identifying any chromatin loop as having its origin in any given pair of chromosomes, because the nucleus enters on a complete resting stage at the close of the presynaptic mitosis and the identity of the chromosomes is lost. Further studies may, however, give results that point to a connection between the two even if they do not make the demonstration. For example, I have seen the union of chromosomes by the polar ends only, in the telophases of the last sporogenous division, and I failed to find, although I searched very closely, the formation of a spireme, but in the place of it the *pairs* of chromosomes appeared to be united at the polar ends. A continuous spireme may not be formed in this division. It is conceivable therefore that the chromosome pairs which enter the resting condition may be identical pair for pair with the loops which are formed later.

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* Cannon, 2.

† Montgomery, *l. c.*

‡ Sutton, *l. c.*

Mottier [*] has described processes in the second maturation division which should be considered in connection with the earlier nuclear divisions as well. In the metaphase of the second division the chromosomes are brought into the paired position in the nuclear plate by the action of the fibers of the spindle; that is, the pairing here is probably due to the activity of the achromatic elements. This seems to make unnecessary the conception of the preliminary pairing of the chromosomes as a direct preparation for heterokinesis, since the spindle can distribute the chromosomes at its will, so to speak. It should be considered, however, that the rings are bivalent, and are probably formed without the intervention of the fibers, since the rings antedate the formation of the spindle itself. Also, if my observation is correct, the spindle fibers are not instrumental in segregating the chromosomes in the presynaptic division, because in that case, with possibly one exception, the pairing was not observed until the chromosomes were at the poles of the spindle and hence probably after the work of the fibers of that dividing nucleus was done. So it may well be that there is not only a difference in the homologies of the chromosome-pairs of the metaphase of the second division and those of the presynaptic one, but a difference in their affinities as well; consequently influences, whatever they may be, other than those of the spindle, may cause the earlier pairing.

The foregoing considerations are based upon the idea of the individuality of the chromosomes and upon that of their being qualitatively unlike.[†] If these conceptions are valid we should

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[*] Mottier, D. M. The behavior of the chromosomes in the spore mother-cells of higher plants, etc. Bot. Gaz. 35: 250. 1903.

[†] The results of Rosenberg's studies (see bibliography) on the sporogenesis of the natural hybrid between *Drosera longifolia* and *Drosera rotundifolia* seem to throw objections in the way of too strict a conception of the individuality of chromosomes in hybrid plants. Rosenberg finds that the reduced number of chromosomes in the *Drosera* hybrid may be 10, as in *D. rotundifolia*, or 20, as in *D. longifolia*, or 15, which is half the somatic number in the hybrid. He also finds some evidence indicating that part of the chromosomes may be made up of four portions of chromosomes each, and others of two halves of chromosomes each; the former kind are also larger. In any case it is difficult to reconcile Rosenberg's results with the idea that the chromosomes are distinct morphological entities; the results point rather to the preservation by a portion of the spores of the purity of the chromatin, a fact which may prove disconcerting to recent critics in this field (Cook; see bibliography). It should be

have spores which might be of pure descent or might not be so according to the manner of the orientation of the segments in the metaphase of the first division. The chromosomes might be associated and distributed by chance as I have recognized (Cannon, 1) and as Sutton has dwelt on at length.* What the connection of the chance distribution of the chromosomes may be with the distribution of the characters among the hybrids is not at all clear, since the relation of the chromosomes to the characters is not known, but the cytologist has abiding faith that there is some connection which will be demonstrable with the microscope, and he looks to the field of hybrids and of hybridization as a new opportunity for experimentation by which to supplement and to substantiate the results of his studies. Experimentation and cytological studies on hybrid forms in which the number of chromosomes is known and in which the number of characters has been determined should show a connection, if there is one, between the number of characters that are transmissible and the number of the chromosomes and their morphology. I wish here to call attention to what very likely is merely a chance coincidence, but nevertheless suggestive and interesting, namely, to the agreement in the number of the groups of constant differentiating characters as given by Mendel for the peas used by him in experiments with the reduced number of chromosomes in the peas. As given by Bateson (Bateson, 1), the characters are (*a*) differences in the length and color of the stem; (*b*) in the size and form of the leaves; (*c*) in the position, color and size of the flowers; (*d*) in the length of the flower-stalk; (*e*) in the color, form and size of the pods; (*f*) in the form and size of the seeds; (*g*) in the color of the seed-coats and cotyledons. In the peas there are evidently more appreciable characters than chromosomes, and therefore the chromosomes bear more than one character each. If then the chromosomes maintain their individuality certain characters might be associated together in the same chromosome, and might be

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borne in mind, however, that a difficulty in drawing conclusions at present from the results of Rosenberg's studies of the sporogeny of the *Drosera* hybrid may lie in the partial sterility of the form. (See Focke, Pflanzenmischlinge, 155.) Further work on this hybrid is promised and will be awaited with interest.

* Sutton, W. S. The chromosomes in heredity. Biol. Bull. 4: 231. 1903.

coupled together in the hybrid organism, not being capable of separating from each other — correlations are not unknown among hybrids. The idea suggests itself that the case might be very different if the number of the chromosomes in relation to that of the characters were greater than in the pea; the chance association and distribution of chromosomes representing portions of characters might not bring about so evident a distribution of characters in the hybrid generations, the Mendelian reversions. May it not be possible then that fortune favored Mendel when he selected for his experimentation plants which had so small a number of chromosomes?*

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* The data at hand showing the number of chromosomes in the somatic cells of Mendelian hybrids are unfortunately not complete. According to Wilson (The Cell, 206), in wheat there are 16 chromosomes, and in cattle and rats the number is probably the same; the mouse has 24 chromosomes; according to the present study the pea has 14. On the other hand, there are 56 chromosomes in the somatic nuclei of hybrid cotton, but the nature of the variations in the cotton, whether or not Mendelian, has not, I believe, been determined.

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Explanation of Plates

NOTE.—A Zeiss microscope with a 2.00 mm. homogeneous oil-immersion objective and a number 18 eye-piece were used, together with a camera lucida, in making all of the sketches in plates 17 and 18.

PLATE 17

FIGS. 1–3. Fillbasket, pure race. Anaphase of last sporogenous division; pairing of the chromosomes not well marked. The three sketches were made from one nucleus.

FIG. 4. Fillbasket, pure race. Late anaphase of the last sporogenous division. The chromosomes are uniting in pairs. One chromosome is in the section next to the one from which the sketch was made.

FIG. 5. Fillbasket × Debarbieux. Nuclear plate of the last sporogenous division. Six chromosomes are associated in pairs.

FIG. 6. Fillbasket × Debarbieux. Anaphase of last sporogenous division showing a pairing of the chromosomes.

FIG. 7. Fillbasket × Debarbieux. Early reconstruction stage in last sporogenous division, showing the fusing of the pairs of chromosomes at their polar ends; three chromosomes are in the adjoining section. The connecting chromatin is exaggerated in the sketch.

FIG. 8. Fillbasket × Debarbieux. Same division as the preceding; the connecting ring of chromatin does not become reticulated as early as the remainder of the chromosomes.

FIG. 9. Fillbasket × Debarbieux. Same division as the preceding sketch; shows fusing of chromosomes at the polar ends.

FIGS. 10–14. Fillbasket × Debarbieux. Figs. 10–12 are sketches of metaphase of sporogenous division, *probably not the last one*, and figs. 13 and 14 are anaphases of two similar divisions. These do not show pairing of the chromosomes.

PLATE 18

FIGS. 15–17. Express × Serpette. Prophase of the first maturation mitosis, heterotype rings.

FIGS. 18, 19. Fillbasket × Debarbieux. Metaphase of the first maturation division.

FIG. 20. Fillbasket × Debarbieux. Chromosomes from the metaphase of the first division.

FIG. 21. Fillbasket × Debarbieux. Nuclear plate, first division, showing the reduced number, seven, of chromosomes.

FIGS. 22, 23. Fillbasket × Debarbieux. Anaphase of the first maturation mitosis; in the latter sketch one of the chromosomes has failed to divide; this was the only abnormality which was seen in the sporogeny of the pea hybrids.

FIGS. 24, 25. Fillbasket × Debarbieux. All of the chromosomes of one daughter nucleus are shown; the number of chromosomes is seven.

FIG. 26. Fillbasket × Debarbieux. Early reconstruction stage of a daughter nucleus; one chromosome is in the adjoining section. No splitting of the segments is to be seen.

FIG. 27. Fillbasket × Debarbieux. Metaphase of the second maturation division.

FIG. 28. Fillbasket × Debarbieux. Typical chromosomes from the metaphase of the second division.

FIGS. 29, 30. Fillbasket × Debarbieux. Metaphase of the second division showing the reduced number of chromosomes to be seven; the nuclei are sister nuclei.

FIG. 31. Fillbasket × Debarbieux. Resting nucleus of tetrad; shows complete resting condition.

FIG. 32. Fillbasket × Debarbieux. Metaphase of the first nuclear division of tetrad ; germination of microspore.

FIG. 33. Fillbasket × Debarbieux. Reconstruction of the vegetative and the generative nuclei in first mitosis of tetrad nucleus.

PLATE 19

FIG. 34. Express, pure race. (Reduced.)

FIG. 35. Serpette, pure race. (Reduced.)

FIG. 36. Express × Serpette, showing Express reversion. (Reduced.)

FIG. 37. Express × Serpette, showing Serpette reversion. Both of the figures of Express × Serpette were drawn from plants selected at random. They are representative second generation forms. (Reduced.)

Hepaticae of Puerto Rico

III. HARPALEJEUNEA, CYRTOLEJEUNEA, EUOSMOLEJEUNEA AND TRACHYLEJEUNEA

BY ALEXANDER W. EVANS

(WITH PLATES 20–22)

HARPALEJEUNEA

The subgenus *Harpa-Lejeunea* as first limited by Spruce included three sections.* In the first of these, *Cardiostipa,* the underleaves were described as cuneate-obcordate or cuneate-bifid with very obtuse angles or segments; while in the second, *Cyclostipa,* they were said to be suborbiculate and, with a single exception, bifid to the middle with acute or very rarely obtuse segments. The exception was *Lejeunea holostipa* Spruce, a species with undivided underleaves. The third section, *Strepsi-Lejeunea,* was made up of more robust forms with strongly thickened cell-walls and much larger underleaves. Spruce implied at the beginning that this third section was almost of subgeneric value and a few years afterwards wrote of it as a subgenus. When Schiffner elevated Spruce's subgenera to generic rank, he made two genera, tentatively at least, out of the subgenus *Harpa-Lejeunea* as originally defined.† For the first of these, which still included the sections *Cardiostipa* and *Cyclostipa* of Spruce, he retained the name *Harpalejeunea.* To the second he naturally gave the name *Strepsilejeunea.* Both of these genera are fully recognized by Stephani.‡

The sections *Cardiostipa* and *Cyclostipa* are really of unequal value. *Cardiostipa* is a very natural group, characterized especially by a peculiar type of underleaf, while *Cyclostipa* is made up of rather heterogeneous elements. This fact was clearly recognized by Spruce, who stated that his three species, *L. holostipa*, *L.*

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* Hep. Amaz. et And. 164. 1884.

† Engler & Prantl, Nat. Pflanzenfam. 1^3: 126, 127. 1893.

‡ Hedwigia, **35**: 97, 127. 1896.

megalantha and *L. erectifolia*, although included in *Cyclostipa*, might perhaps be better placed among the species of *Micro-Lejeunea.* In 1887, he transferred *L. erectifolia* to this subgenus and, in 1894, pursued the same course with *L. holostipa* and *L. megalantha.* Even the removal of these three species does not leave a wholly uniform residue, and it is probable that the remaining species will in time be distributed among other genera of the Lejeuneae. In the light of our present knowledge, it seems wisest to restrict the name *Harpalejeunea* to the section *Cardiostipa*, fully recognizing the close relationship of this emended genus to certain of the *Cyclostipae* as well as to the genera *Strepsilejeunea* and *Trachylejeunea.*

The genus *Harpalejeunea* as thus restricted is composed of small species, the majority of which are tropical, and it is apparently best represented in the tropical forests of America. The genus, however, is not restricted to the tropics. Several well-marked species are known from Patagonia and New Zealand, and *H. ovata* (Hook.) Schiffn., which may be considered the type of the genus, is now known in western Europe from Norway to Portugal and in the eastern United States from Virginia to Georgia. Comparatively few of the species grow on living leaves and still fewer occur on rocks. Several species are found creeping over large caespitose hepatics, such as species of *Bazzania* or *Schistochila*, but the majority prefer the trunks of trees or rotten logs, where they either grow mixed with other prostrate hepatics or form pure thin mats of considerable extent.

The leaves of *Harpalejeunea* are characterized by widely spreading, falcate-ovate lobes, which are gradually narrowed toward the apex. In some cases the apex, which is often reflexed, is extended as a long and slender acumen; in other cases it is more or less bluntly pointed. Intermediate conditions are frequent, and a considerable degree of variation may often be found in a single species. The margin of the lobe varies from entire to sharply spinose, and in this respect, also, certain species are exceedingly variable. The lobule is of fair size and is strongly inflated with an arched keel, the latter forming a distinct angle with the postical margin of the lobe. The free margin of the lobule is strongly involute, and the apex is tipped with a single projecting cell. At the proximal base of this cell, which is commonly more or less curved, there is a slight depression in which a hyaline papilla is situated, very much as in *Drepanolejeunea*. The apical tooth and the lunulate sinus connecting it with the end of the keel assist in forming the opening into the water-sac. Sometimes the latter widens out abruptly just within the opening, but there is commonly a narrow and curved passage-way leading from the enlarged part of the water-sac to the external air. The cells of the lobes are comparatively small and are commonly plane or nearly so on their free surfaces; their vertical walls are either slightly and uniformly thickened or show small but distinct trigones. In a number of species a distinct group of four elongated cells may be detected at the base of the lobe, similar in many respects to those found in *Drepanolejeunea subulata* and its allies. Usually, however, the two cells of this group which are turned toward the antical margin of the lobe become modified into bulging ocelli, and sometimes one or both of the remaining cells undergo a similar transformation. In other species the position of the ocelli is less definite, but their occurrence in some part of the lobe can almost always be demonstrated.

The underleaves of *Harpalejeunea* are unique among the Lejeuneae. They are of small size and widen abruptly from a narrow base into an obcordate expansion, the apical sinus being shallow and varying from lunulate to subacute; the lobes of the underleaves are more or less divergent and are broad and rounded at their extremities.

The species of *Harpalejeunea* are almost always dioicous. The branch bearing the female inflorescence varies greatly in length but the flower itself is invariably subtended by one or two innovations. The perichaetial bracts are more bluntly pointed than the leaves and are sometimes narrowly winged along the keel. The perianth is sharply five-keeled in the upper part, but the keels, although distinctly winged in several species, are never produced as horns. Here, again, the genus shows a certain approach to *Drepanolejeunea subulata* and *D. anoplantha*.

Three species of *Harpalejeunea* from Puerto Rico have been studied by the writer. The first of these is much more abundant than the others and was at one time referred by Stephani to *Lejeunea* (*Harpa-Lej.*) *stricta* Lindenb. & Gottsche, a species originally known from Mexico. Although closely related to *L. stricta*, the Puerto Rico plant is now regarded by Stephani as specifically distinct, and it is described in the present paper as new. The second species studied is *H. uncinata* Steph., heretofore known from several other West Indian islands; the third is a rare epiphyllous species, which is apparently undescribed.

A fourth species from Puerto Rico, *Lejeunea patentissima* Hampe & Gottsche,* is also referred to *Harpalejeunea* by Stephani † and by Schiffner.‡ The original material of this species was collected by Schwanecke, and there seems to be no evidence of its having been found on the island a second time. The type-specimens are preserved in the Gottsche herbarium at Berlin and in the Hampe herbarium in the British Museum. Unfortunately these specimens are fragmentary and for the most part sterile. Even the vegetative organs, however, indicate that the plant is not a typical *Harpalejeunea*, but that it has much more in common with *Ceratolejeunea*, and the single preserved perianth shows conclusively that the species should be referred to the latter genus. *Lejeunea patentissima* will not be included, therefore, among the species of *Harpalejeunea*, the descriptions of which immediately follow.

Harpalejeunea subacuta sp. nov.

Lejeunea (*Harpa-Lejeunea*) *stricta* Steph. Hedwigia, **27**: 291. 1888. Not *Lejeunea stricta* Lindenb. & Gottsche; G. L. & N. Syn. Hep. 756. 1847.

Pale or bright green, often becoming brownish upon drying, growing in depressed mats: stems 0.05 mm. in diameter, prostrate but rather loosely adherent to substratum, very sparingly branched, the branches widely spreading: leaves contiguous to slightly imbricated, the lobes widely spreading, convex, often reflexed at the apex, falcate-ovate, 0.3 mm. long, 0.17 mm. wide, attached by an almost longitudinal line of insertion, gradually narrowed beyond lobule to apex, margin entire or nearly so, antical margin decurrent by a single cell, strongly curved but rarely arching beyond axis, postical margin straight or slightly curved, apex varying from rounded to subacute, on leaves of small branches sometimes acute and occasionally tipped with two superimposed cells; lobule ovoid, 0.17 mm. long, 0.1 mm. wide, strongly inflated, somewhat constricted in outer part thus forming a curved and narrow passage-way leading into the water-sac, keel strongly arched, slightly roughened in outer part from projecting cells, free margin more or less involute, straight or nearly so to apex then passing by a broad and shallow sinus to end of keel, apical tooth slightly curved; cells of lobe plane or nearly so, averaging 10 μ at edge and 16 × 12 μ in the middle and toward the base, walls slightly thickened with very indistinct trigones and occasional intermediate thickenings; ocelli commonly two, placed end to end at the base of the lobe, 30 μ long and 18 μ wide: underleaves distant, broadly obcordate, 0.5 mm. long, 0.07 mm. wide, narrowed toward base, bifid about one fifth with a shallow obtuse sinus and broad, rounded, diverging lobes, each about four cells broad at the base; rhizoids very scanty, sometimes growing from a rudimentary disc in the basal region of an underleaf: inflorescence dioicous: ♀ inflorescence on a leading branch, more rarely on a short branch, innovating on one side, the innovation commonly simple and sterile, rarely floriferous; bracts suberect, somewhat complicate, the keel slightly roughened from projecting cells but not winged, subequally bifid, the lobe ovate to obovate, 0.4 mm. long, 0.25 mm. wide, gradually narrowed to the obtuse or rounded apex, lobule similar to the lobe but narrower, measuring 0.19 mm. in width, margin entire; bracteole connate with one or both bracts at base, oblong, 0.35 mm. long, 0.27 mm. wide, bifid one tenth to one third with lunulate to obtuse sinus and rounded, erect or slightly diverging lobes, margin entire or nearly so; perianth about half exserted, oblong, 0.65 mm. long, 0.35 mm. wide, narrowed toward base, truncate above and with a short narrow beak, sharply five-keeled except in the basal region, the keels rounded above and smooth or slightly roughened along their edges: ♂ inflorescence and mature sporophyte not seen (*pl. 20, f. 1–11*).

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* Linnaea, **25**: 355. 1852.

† Hedwigia, **27**: 288. 1888.

‡ Bot. Jahrb. **23**: 591. 1897.

On bark of trees. North slope of the Luquillo Mountains, *Heller* (1141, type, 4708*a*, 4719 *p. p.*, 4721 *p. p.*, 4729, 4731 *p. p.*, 4731*a*, 4732*a*, 4733, 4734 *p. p.*). El Yunque, *Evans* (3,149). Originally collected by *Sintenis.*

The close relationship which exists between *Harpalejeunea ovata* and *Lejeunea stricta* has already been commented upon by Spruce* and by Stephani.† *H. subacuta* is closely allied to both these plants and the three together constitute a group of species so very similar to one another that the greatest care must be exercised in separating them. At the same time the differential characters, although so slight, appear to be constant.

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* Hep. Amaz. et And. 170. 1884.

† Hedwigia, 27: 291. 1888.

In *L. stricta* the leaves are much more sharply pointed than in *H. subacuta* and commonly end in a row of from two to four cells; the leaf-cells have slightly thinner walls and the trigones are in consequence a little more prominent; the underleaves differ in being about as long as broad (measuring 0.075 mm. in length) and in having less divaricate lobes. The material of *L. stricta* studied by the writer is from Liebmann's original collection and was kindly communicated by Herr Stephani. The specimens are destitute of female flowers and perianths, but these organs, which are fully described by Gottsche,* afford a few additional differences, the bracts being winged along the keel and the keels of the perianth being denticulate in the upper part.

In *Harpalejeunea ovata* the leaves are very similar in shape to those of *H. subacuta*, and the apices of the lobes vary from obtuse to short-acuminate. The northern species, however, is a little more robust, but at the same time the leaf-cells, which measure a little larger than those of *H. subacuta*, are more delicate in texture and show more distinct trigones. The underleaves of *H. ovata* measure 0.08 mm. in length and 0.1 mm. in width and the apical sinus is shallow and commonly lunulate, in many cases being scarcely evident. The perichaetial bracts and bracteoles agree pretty closely in the two species, but those of *H. subacuta* are relatively broader and the bracteal lobes are more nearly equal in size.

HARPALEJEUNEA UNCINATA Steph.

Harpalejeunea uncinata Steph. Hedwigia, **35**: 97. 1896.

Pale green, often becoming brownish upon drying, growing in depressed mats: stems 0.035 mm. in diameter, prostrate but rather loosely adherent to substratum, sparingly branched, the branches widely spreading: leaves contiguous to slightly imbricated, the lobe widely spreading (in outer part), convex, sometimes reflexed at the apex, falcate-ovate, 0.3 mm. long, 0.15 mm. wide, attached by an almost longitudinal line of insertion, margin entire near antical base, otherwise irregularly crenulate or denticulate from projecting cells, antical margin decurrent by a single cell, strongly curved and arching partly or entirely across axis, postical margin straight or slightly curved, apex abruptly apiculate to cuspidate, ending in a single row of from two to five cells, on leaves of slender branches sometimes obtuse; lobule ovoid, 0.15 mm. long, 0.08 mm. wide, strongly inflated, abruptly constricted in outer part, thus forming a curved and narrow passage-way leading into the water-sac, keel strongly arched, smooth or nearly so, free margin either involute or appressed to lobe, passing beyond apex by a shallow sinus to end of keel, apical tooth slightly curved; cells of lobe plane or nearly so, averaging 13 × 11 μ, scarcely varying in size in different parts of the lobe, walls slightly thickened with scarcely evident trigones and occasional intermediate thickenings; ocelli commonly two, placed end to end at the base of the lobe, 23 μ long and 14 μ wide: underleaves distant, broadly obcordate, 0.05 mm. long, 0.07 mm. wide, narrowed toward base, bifid about one third with an obtuse sinus and broad, diverging, rounded or truncate lobes, each about four cells wide at base and three cells long; rhizoids scanty, not growing from a disc: inflorescence dioicous: ♀ inflorescence sometimes on a leading branch, sometimes on a short branch, innovating on one side with a commonly sterile innovation; bracts obliquely spreading, complicate, unequally bifid, the lobe ovate to obovate, 0.4 mm. long, 0.25 mm. wide, apex obtuse to rounded, margin more strongly crenulate or denticulate than in the leaves, keel often with a narrow entire wing one or two cells wide, lobule similar in shape to lobe, 0.35 mm. long, 0.19 mm. wide, apex sometimes retuse, margin slightly and irregularly crenulate or denticulate; bracteole slightly connate with one bract, oblong-obovate, 0.3 mm. long, 0.25 mm. wide, bifid about one third with slightly diverging blunt divisions, margin as in lobule; perianth about half exserted, oblong, 0.6 mm. long, 0.35 mm. wide, slightly narrowed toward base, truncate above and with a short beak, sharply five-keeled except in basal region, the keels narrowly winged in the upper part with dentate to spinose wings, the projections consisting of from one to three cells: ♂ inflorescence and mature sporophyte not seen (*pl. 20, f. 12–24*).

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* Mex. Leverm. 198. 1863.

On bark of trees. North slope of the Luquillo Mountains, *Heller* (4763 *p. p.*). Also known, in sterile condition, from the following localities: Cuba, *Wright;* Santo Domingo, *Eggers;* Trinidad, *Crueger.*

Although the writer has been unable to secure authentic specimens of *H. uncinata*, his determination of the species has been confirmed by Herr Stephani. The description given above supplements, in several important respects, the original description, which was drawn from sterile material. *H. uncinata* is about the same size as *H. subacuta* and resembles it closely at first glance. It is remarkable for the long and slender apices of its lobes, which stand out from the axis at an angle of 90° or more in explanate leaves. This character will at once distinguish the species from *H. subacuta* and the denticulate or crenulate leaf-margins will also be of assistance. Lobules, leaf-cells, ocelli and underleaves are strikingly alike in the two species. In the perichaetial bracts of *H. uncinata*, certain of the foliar characters become accentuated while others disappear. The margin of the lobe, for example, is much more toothed than on ordinary leaves, but the apex is rounded or obtuse instead of being extended as a filiform point. Even when a tooth is present at the apex, it cannot be distinguished from the neighboring teeth. The distinctly toothed bracts and bracteoles and the dentate or spinose wings on the keels of the perianth are also good differential characters in separating the species from *H. subacuta*.

Harpalejeunea heterodonta sp. nov.

Pale green, scattered among other epiphyllous hepatics: stems 0.06 mm. in diameter, prostrate and closely adherent to substratum, irregularly branched, the branches obliquely to widely spreading: leaves distant to subimbricated, the lobe widely spreading (in outer part), plane or slightly convex even in apical region, falcate-ovate, 0.35 mm. long, 0.2 mm. wide, gradually narrowed into a long-attenuate apex, attached by an almost longitudinal line of insertion, antical margin decurrent by a single cell, straight or nearly so and entire near base, then strongly curved and varying from irregularly crenulate to spinose, the crenulations being slightly projecting cells and the spines sometimes attaining a length of five cells and a width of three cells at the base, postical margin straight or slightly curved, obscurely crenulate from projecting cells, apex commonly terminating in a row of two or three cells; lobule ovoid, 0.17 mm. long, 0.1 mm. wide, strongly inflated, abruptly constricted in outer part thus forming a very short, slightly curved passage-way leading into the water-sac, keel strongly arched, slightly roughened in outer part from projecting cells, free margin straight or nearly so, involute to beyond apex then passing by a shallow lunulate sinus to end of keel, apical tooth short and slightly curved; cells of lobe plane or nearly so, averaging 14 μ in diameter at edge and 18 × 16 μ elsewhere, thin-walled, trigones and occasional intermediate thickenings small but distinct; ocelli commonly two, placed end to end at the base of the lobe, 30 μ long, 21 μ wide: underleaves distant, broadly obcordate, 0.07 mm. long, 0.08 mm. wide, narrowed toward base, bifid one fourth to one third with a shallow lunulate sinus and broad, diverging rounded lobes, each five or six cells long and four or five cells wide at base, margin obscurely crenulate from projecting cells; rhizoids numerous, rarely growing from a rudimentary disc: inflorescence not seen (*pl. 21, f. 1–9*).

On living leaves. El Yunque, *Evans* (20 *p. p.*, 160 *p. p.*).

Although *H. heterodonta* is known in sterile condition only, its foliar characters are so peculiar that it can hardly be confused with other members of the genus. When the leaf-margins are only slightly crenulate, the species bears some resemblance to *H. uncinata*, but even on such specimens it is usually possible to find leaves with more strongly marked teeth, and the leaf-cells are constantly a little longer than in Stephani's species and have thinner walls with more evident trigones. The marginal spines of *H. heterodonta* are less frequent on robust stems than on slender branches.

Apparently *Lejeunea* (*Harpalejeunea*) *tridens* Besch. & Spruce* is closely related to the present species. *L. tridens* is likewise West Indian; it was originally known from Guadeloupe, but has since been reported by Spruce from the neighboring island of Dominica.† The leaves of this species, as its name implies, are almost constantly tridentate and the teeth are usually long and slender enough to be called spines. Judging from the published figures of *L. tridens*, the regularity of these foliar teeth or spines gives the plant a very different appearance from what we find in *H. heterodonta*. *L. tridens* differs, also, in its place of growth and in its thick-walled leaf-cells.

CYRTOLEJEUNEA

Attention has already been called to *Lejeunea holostipa* Spruce, a species originally placed by its author in the subgenus *Harpa-Lejeunea* and afterwards transferred to *Microlejeunea*. This interesting plant is widely distributed in tropical America, and has recently been found in Puerto Rico; it is almost always mixed with other hepatics and is rarely fertile. Although first described by Spruce, *L. holostipa* was also known to Gottsche from specimens collected in Cuba by C. Wright and was distributed in the *Hepaticae Cubenses* under the name "*Lejeunea pseudocucullata* G." Within recent years this manuscript species has been described by Stephani as an *Archilejeunea* and by Schiffner as a *Euosmolejeunea*, not appreciating, apparently, that it was synonymous with *Lejeunea holostipa*. It is evident that the greatest diversity of opinion exists regarding the systematic position of the species. This is due to certain very peculiar characters which it presents, and, as a matter of fact, it does not fit naturally into any one of these four divisions of the Lejeuneae to which it has been referred. It seems advisable, therefore, to propose a new genus for its reception, a course already suggested by Schiffner. The generic characters of this new genus and the specific characters of its single known species are as follows:

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* Bull. Soc. Bot. France, **36**: clxxxi. *pl. 13*. 1890.

† Jour. Linn. Soc. Bot. **30**: 341. 1894.

Cyrtolejeunea gen. nov.

Plants small, bright green: stems prostrate, sparingly branched: leaves distant to subimbricated, the lobe convex, not widely spreading, rounded at the apex, entire; lobule strongly inflated, free margin with a long terminal tooth composed of a single cell and bearing a hyaline papilla in a slight depression at its distal base (*i. e.*, at the beginning of the apical sinus): cells of lobe convex: underleaves orbicular, undivided, entire: ♀ inflorescence on a leading branch, innovating on one side; bracts unequally bifid; bracteole shortly bifid; perianth sharply five-keeled and distinctly beaked, the keels not produced as horns. (Name from *κυρτος*, curved or convex, and *Lejeunea*.)

Cyrtolejeunea holostipa (Spruce)

Lejeunea (*Harpa-Lejeunea*) *holostipa* Spruce, Hep. Amaz. et And. 171. 1884.

Lejeunea (*Microlejeunea*) *holostipa* Spruce, Jour. Linn. Soc. Bot. **30**: 348. 1894.

Archilejeunea pseudocucullata Steph. Hedwigia, **34**: 61. 1895.

Lejeunea pseudocucullata Gottsche; Wright, Hep. Cubenses; Schiffn. Bot. Jahrb. **23**: 583. 1897 (as synonym).

Euosmolejeunea pseudocucullata Schiffn. *l. c.*

Bright green, sometimes becoming brownish or yellowish upon drying, growing in depressed tufts or more commonly mixed with other bryophytes: stems prostrate but not closely adherent to substratum, 0.04 mm. in diameter; branches widely spreading, sometimes with rudimentary leaves: leaves distant to slightly imbricated, the lobe obliquely spreading, strongly convex and revolute along postical margin, ovate to orbicular-ovate, slightly or not at all falcate, 0.25 mm. long, 0.17 mm. wide, attached by an almost longitudinal line of insertion except at antical base, margin entire, antical margin more or less curved, sometimes arching partly or entirely across axis, postical margin somewhat curved in explanate leaves, apex broadly rounded; lobule sphaero-ovoid, 0.17 mm. long, 0.12 mm. wide, strongly inflated, keel, convex and strongly arched, roughened from projecting cells, free margin straight and entire, involute to base of apical tooth, sinus broad and shallow, apical tooth straight and slender, forming a continuous line with the inner part of the free margin when flattened out; cells of lobe convex, averaging 9 μ at the margin of the lobe and 14×12 μ in other regions, either thin-walled throughout or with minute but more or less distinct trigones; ocelli none: underleaves distant, orbicular, 0.08 mm. long, subcuneate at the base, rounded or very rarely bicrenulate at the apex, margin entire; rhizoids commonly scanty, growing from the bases of the underleaves: inflorescence dioicous: ♀ inflorescence with a sterile innovation, bracts scarcely complicate, shortly and unequally bifid, the lobe broadly orbicular-ovate, 0.4 mm. long, 0.3 mm. wide, entire, rounded at apex, lobule lanceolate, acute, 0.3 mm. long, 0.07 mm. wide; bracteole free or nearly so, obovate, strongly convex postically, 0.3 mm. long, 0.25 mm. wide, bifid one fourth or less with broad rounded lobes and obtuse sinus; perianth about half exserted, oval to obovoid, 0.7 mm. long, 0.35 mm. wide, rounded at the apex and with a rather long and slender beak, narrowed toward base, sharply five-keeled in the upper part, the antical keel a little lower than the others, keels sometimes obscurely winged, surface of perianth smooth: ♂ inflorescence usually intercalary on a leading branch, bracts in one to four pairs, strongly concave and inflated, shortly and subequally bifid, the lobes and lobules rounded; bracteoles (when present) similar to ordinary underleaves; antheridia and mature sporophytes not seen (*pl. 21, f. 10–23*).

On bark of trees, rarely on living leaves. El Yunque, *Evans* (21 *p.p.*, 46 *p.p.*). The type-specimens were collected by *Spruce* in Brazil and distributed in *Hepaticae Spruceanae*. Other stations for the species are the following: Cuba, *Wright;* Venezuela, *Moën;* St. Vincent, *Elliott.*

In spite of its undivided underleaves the systematic position of *Cyrtolejeunea* seems to be among the Lejeuneae Schizostipae rather than among the Holostipae, where it was placed by Stephani. It shows, to be sure, certain characters in common with *Archilejeunea* such as its single subfloral innovation and five-keeled perianth, but it is so much smaller than typical members of this genus and so much more delicate in texture that it would hardly be natural to include it among them. It possesses, moreover, a lobule of an entirely distinct type, and this will serve to separate it not only from *Archilejeunea* but from *Harpalejeunea*, *Microlejeunea* and *Euosmolejeunea* as well.

The lobule in the Lejeuneae often affords characters of more than specific importance. Certain of these characters have long been recognized by writers; others either have been overlooked or have not been fully appreciated, partly because the lobule is not always well developed, partly because it can rarely be satisfactorily studied without dissecting off the leaves from the stem and flattening them under pressure. These characters relate not only to the shape, size and degree of inflation of the lobule but also to the peculiarities of its free margin, with respect especially to the apex and the position of the hyaline papilla which is commonly found in the immediate vicinity of the apex. Throughout the genus *Drepanolejeunea*, for example, a more or less curved tooth, composed of a single projecting cell, is found at the apex of the lobule, and the hyaline papilla is situated at the proximal base of this tooth in a depression. Essentially the same type of lobule is developed in *Harpalejeunea* (*pl. 20, f. 9, 19*), *Trachylejeunea* and *Leptolejeunea*. The curved tooth in all these genera plays an important part in the formation of the opening into the water-sac, and, in the case of *Leptolejeunea exocellata* and its immediate allies, exhibits marked modifications due perhaps to the presence of the large basal ocellus in the lobe. In *Microlejeunea* the apex is tipped with a single slightly projecting cell which is blunt and scarcely or not at all curved. The hyaline papilla in this genus is sometimes borne on the projecting cell itself but commonly occupies the same position as in the other genera to which allusion has just been made. In *Cyrtolejeunea* the lobule bears at its apex a long and slender sharp-pointed and straight tooth, consisting of a single projecting cell, and the hyaline papilla is borne at its distal base (*pl. 21, f. 18, 19*). In *Euosmolejeunea* the papilla is likewise borne at the distal base of the apical tooth but the tooth itself is short and rather bluntly pointed, projecting only for a short distance beyond the adjoining cells (*pl. 22, f. 6*).

Of all the genera to which *Cyrtolejeunea holostipa* has been referred, it is perhaps most closely related to *Microlejeunea*, from which its undivided underleaves and peculiar lobules should doubtless exclude it. From *Harpalejeunea* it differs not only in these characters, but also in its rounded obliquely spreading leaves and in its lack of ocelli; from *Euosmolejeunea* it differs in its small size and green color, as well as in its small leaf-cells with delicate walls. There are no Puerto Rico species with which it could readily be confused.

EUOSMOLEJEUNEA

The typical members of the genus *Euosmolejeunea* are among the most easily recognized Lejeuneae of the tropics. They are fairly robust for species with bifid underleaves and are usually characterized by a peculiar yellowish green color and by a rather pronounced odor. At first glance they perhaps bring to mind *Omphalanthus filiformis*, which, however, is even more robust and is further distinguished by its undivided underleaves and by its perianth without keels. The leaves in *Euosmolejeunea* have well-developed lobes and small lobules; the lobes are broad and spread widely from the stem, they are more or less convex and are commonly broad and rounded at the apex and their margins are entire or nearly so. The lobules are strongly inflated, and their free margins are involute to beyond the apex; the latter is tipped by a single slightly projecting cell, which is straight and not sharply pointed. The hyaline papilla is at the distal base of this projecting cell. The leaf-cells are firm and are frequently convex; trigones are conspicuous, but intermediate thickenings are wanting or exceedingly rare. Ocelli are also wanting. The underleaves are large and orbicular, in certain species extending almost to the apices of the lobes; they are commonly cordate at the base, and the apical sinus varies from lunulate to acute. In a few species the underleaves are much smaller and are cuneate at the base; in one or two species which have been referred to the genus, the underleaves are undivided. The ♀ inflorescence is sometimes borne on a short branch and sometimes on a leading branch, but it is invariably subtended by one or two innovations. The bracts are similar to the leaves, but are sometimes sharply pointed. The perianth is sharply five-keeled, but is never provided with horns; its surface is often roughened by projecting cells. In common with many other genera of the Lejeuneae the basal region of the perianth becomes elongated after fertilization and thus modifies to a considerable extent the form of the organ. Neither gemmae nor propagula have been noted in the genus.

The affinities of *Euosmolejeunea* are not altogether clear, but it is hardly probable that it is closely related to any of the other genera treated in the present paper. It is introduced here largely for comparison with *Cyrtolejeunea*, and the most important differences between the two genera have already been noted. It is probable that *Cheilolejeunea* and *Pycnolejeunea* are much nearer allies.

The species of *Euosmolejeunea* are commonly found on the bark of trees or on rotten logs, more rarely on shaded rocks or stones. In many cases they grow mixed with other hepaticae, usually Lejeuneae, but one finds, not infrequently, broad pure mats of considerable size.

Three species of the genus are now known from Puerto Rico, viz: *E. duriuscula*, *E. opaca* and *E. trifaria*. The first two of these have a wide distribution in tropical America and are also known from the subtropical regions of the United States along the Gulf of Mexico. *E. trifaria* is even more widely distributed, being found in nearly all the tropical regions of the globe. Since *E. duriuscula* and *E. opaca* have recently been described and figured by the writer,* nothing about them is noted here except their distribution on the island. *E. trifaria*, however, is described in full.

Euosmolejeunea duriuscula (Nees) Evans

On rotten logs. North slope of the Luquillo Mountains, *Heller* (4649 *p.p.*, 4755). Also collected by *Sintenis* (52, 53).

Euosmolejeunea opaca (Gottsche) Steph.

On trees and rocks. North slope of the Luquillo Mountains, *Heller* (4325, 4761 *p.p.*). Three miles east of Santurce,

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* Mem. Torrey Club, **8**: 135–141. *pl. 18, f. 12–23. pl. 19, f. 1–11.* 1892.

Heller (461). Utuado, *Underwood & Griggs.* El Yunque *Evans* (1).

EUOSMOLEJEUNEA TRIFARIA (Nees) Schiffn.*

Yellowish green, varying to bright green and often becoming brownish upon drying, growing in depressed mats: stems 0.1 mm. in diameter, sparingly and irregularly branched, the branches obliquely to widely spreading: leaves loosely imbricated, the lobe widely spreading, usually convex and more or less revolute at the apex, broadly ovate-orbicular, falcate, 0.5 mm. long, 0.47 mm. wide, attached by an almost longitudinal line of insertion except for a very short distance at antical base, margin vaguely and irregularly crenulate from projecting cells, antical margin strongly curved from the base, arching in most cases considerably beyond axis, postical margin strongly curved and forming a distinct angle (usually of about 90°) with the keel, apex broad and rounded; lobule triangular-ovoid, 0.15 mm. long, 0.09 mm. wide, strongly inflated but commonly constricted near orifice, keel straight or slightly curved, roughened from projecting cells, free margin strongly involute to beyond apex, then passing by a short lunulate sinus to end of keel, entire and almost straight when flattened out, apical tooth straight and continuous with inner part of free margin, short and bluntly pointed, normally appressed to the lobe and taking part in the formation of the opening into the water-sac; cells of lobe averaging 14 μ at edge of leaf, 22 μ in the middle and 25 μ at the base, more or less convex with a distinctly thickened outer wall, trigones large, triangular, with straight or slightly bulging sides, rarely confluent, intermediate thickenings very rare: underleaves loosely imbricated, broadly orbicular, 0.5 mm. long, 0.6 mm. wide, convex postically, shortly bifid — one fourth or less — with an acute to lunulate sinus and erect or slightly connivent divisions, obtuse to acute and often apiculate at the apex, tipped with a single cell or more rarely with two superimposed cells, distinctly cordate at the base and attached by a strongly curved line of insertion, margin and cells as in leaf-lobes; rhizoids commonly present, forming little tufts at the bases of the underleaves: inflorescence autoicous: ♀ inflorescence commonly borne on a leading branch, more rarely on a short branch, innovating usually on only one side, the innovation commonly long and repeatedly floriferous, more rarely short and sterile; bracts unequally bifid, the lobe obliquely spreading, ovate to oblong, 0.65 mm. long, 0.45 mm. wide, apex rounded to very obtuse, margin as in leaves, lobule lanceolate to narrowly oblong, 0.3 mm. long, 0.09 mm. wide, acute to obtuse at the apex; bracteole free, similar to the underleaves but relatively longer, measuring 0.6 mm. in length and 0.5 mm. in width, bifid about one sixth; perianth when young about half exserted, afterwards pushed outward through the growth of the basal region, oblong to oblong-obovate, 1 mm. long, 0.5 mm. wide when well developed, narrowed toward base, broad and rounded or truncate at the apex with a short but distinct beak, sharply five-keeled, the antical keel extending from the apex to about the middle of the perianth, the others extending nearly to the base, surface of perianth more or less roughened from projecting cells: ♂ inflorescence basal or intercalary on a short branch; bracts in two to five pairs, strongly inflated, unequally bifid, the lobe obtusely pointed, the lobule sharper and often apiculate; bracteoles present at base of spike, smaller than the underleaves and more deeply bifid; antheridia in pairs: mature sporophyte not seen (*pl. 22, f. 1–10*).

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* On account of its great variability and wide distribution, *E. trifaria* has many synonyms. A list of these was published by Stephani in 1888 (Hedwigia, **27**: 292), and the whole synonymy was afterwards given very fully by Schiffner (Conspect. Hepat. Arch. Indici, 263. 1898). It seems unnecessary, therefore, to enumerate the synonyms here. The species has been figured by Stephani, under the name *Lejeunea grandistipula* (Bol. Soc. Broteriana, **4**: *pl. 2, f. 19–21.* 1886).

On trees. North slope of the Luquillo Mountains, *Heller* (4719 *p. p.*, 4721 *p. p.*). El Yunque, *Evans* (27, 33). First collected on the island by *Schwanecke*.

So far as we know at present *E. trifaria* is the only American species of *Euosmolejeunea*, in which the inflorescence is autoicous. Even here unisexual individuals occasionally occur, but, since they are usually found in the same mats as typical bisexual individuals, their presence need not often confuse us in recognizing the species. The monoicous inflorescence doubtless accounts for the frequency of perianths in *E. trifaria* as compared with dioicous forms.

Probably the closest ally of *E. trifaria*, in the West Indies at least, is the dioicous *E. opaca*. If for any reason there is difficulty in demonstrating the inflorescence, the slight differences in the vegetative organs are usually distinct enough to separate these two species. *E. opaca* is a little less robust than *E. trifaria*, the lobes of its leaves are less convex, the leaf-cells are plane or nearly so, and the trigones of both leaves and underleaves are less conspicuous. Of course all of these vegetative characters are variable and largely dependent on external conditions, so that the positive determination of immature or poorly developed specimens is not always possible.

TRACHYLEJEUNEA

The genus *Trachylejeunea* is not a very clearly defined group of species. It is characterized primarily by the roughness of its leaves and perianths. This roughness is due in part to very convex cell-walls, in part to the presence of a large median tubercle or wart on each cell. The roughness commonly affects the antical surface of the lobe, the postical surface of the lobule and the outer surface of the perianth, but in some species is scarcely evident except on the keels of the latter organ. Roughness of this character is by no means confined to *Trachylejeunea*. We find it, for example, equally well marked, in many species of *Cololejeunea* as well as in a few species of *Strepsilejeunea* and in certain other genera of the Lejeuneae. Aside from their roughness the leaf-cells of *Trachylejeunea* are variable; sometimes they are thin-walled throughout, sometimes provided with conspicuous local thickenings. Ocelli are usually present at the base of the lobe. The species belonging to the present genus are commonly more robust than in either *Harpalejeunea* or *Strepsilejeunea*. The lobes of their leaves are mostly blunt-pointed and are never acuminate (except in the very aberrant *T. acanthina* (Spruce) Schiffn.); the lobule is inflated and bears a slightly curved apical tooth with a hyaline papilla at its proximal base; the underleaves are rotund and bifid with a narrow sinus and suberect pointed divisions. The ♀ inflorescence is borne on a short branch which, in most species, does not innovate; the perianth is sharply five-keeled in the upper part and the keels, although sometimes obsoletely winged, are never produced as horns.

Comparatively few species of *Trachylejeunea* have been described. The majority of them grow on trees or on rotten logs in tropical forests, but a few are found in the South Temperate Zone. Two species have been recorded from the West Indies: *T. Spruceana* Steph.,* from Guadeloupe, and *T. prionocalyx* (Gottsche) Schiffn.,† from Cuba. Neither of these species has yet been found on Puerto Rico, but a third species, *Lejeunea* (*Trachy-Lejeunea*) *Aquarius* Spruce, occurs in recent collections.

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* Hedwigia, **35**: 138. 1896.

† Bot. Jahrb. **23**: 592. *pl. 15, f. 8–12.* 1897.

Trachylejeunea Aquarius (Spruce)

Lejeunea (*Trachy-Lejeunea*) *Aquarius* Spruce, Hep. Amaz. et And. 185. 1884.

Pale whitish green sometimes tinged with yellowish, growing in depressed mats or mixed with other bryophytes: stems 0.1–0.15 mm. in diameter, sparingly branched, the branches widely spreading: leaves imbricated, the lobe widely spreading, strongly convex and reflexed at the apex, falcate-ovate, sometimes broadly so, 0.6 mm. long, 0.45 mm. wide, attached by an almost longitudinal line of insertion except for a short distance near antical base, margin entire near antical base and also near keel, otherwise crenulate from projecting cells, sometimes obscurely serrulate or denticulate near apex, antical margin straight or slightly incurved near base, then strongly outwardly curved and arching to the middle of the axis or beyond, postical margin slightly curved, apex obtuse to subacute, on leaves of slender branches sometimes acute; lobule ovoid, 0.2 mm. long, 0.1 mm. wide, strongly inflated, keel strongly arched, roughened in outer part from projecting cells and warts, free margin strongly involute to beyond apical tooth, then passing by a very shallow sinus to end of keel, apical tooth slightly curved, hyaline papilla at proximal base of tooth in a depression bounded on the inner side by a second more or less distinct unicellular tooth; cells of lobe with strongly convex outer walls, averaging 18 μ at the margin and 24 μ in the middle, each cell (except near the base) bearing a median, blunt tubercle representing a local thickening of the convex wall, trigones large and conspicuous, rarely confluent, intermediate thickenings wanting; ocelli two to five in number, measuring 65 × 28 μ, situated in a group near the base of the lobe; tubercles occasionally present on margin between adjoining cells; cells of lobule also tuberculate: underleaves distant, broadly orbicular-rhombic, 0.25 mm. long, 0.3 mm. wide, bifid to about the middle with connivent or suberect lobes and narrow acute sinus, not cordate at base, margin entire; rhizoids growing in tufts from the bases of the underleaves: inflorescence autoicous: ♀ inflorescence borne on a short branch, innovating on one side with a short sterile innovation; bracts obliquely spreading, more or less complicate, unequally bifid, the lobe obovate, 0.75 mm. long, 0.45 mm. wide, apex rounded to very obtuse, margin and cells as in leaves, lobule lanceolate, 0.4 mm. long, 0.15 mm. wide, apex obtuse to subacute, margin slightly and irregularly crenulate or verruculose in upper part, cells otherwise smooth or nearly so; bracteole free, oblong to obovate, 0.6 mm. long, 0.3 mm, wide, bifid one eighth to one sixth with obtuse lobes and sinus, margin as in lobule; perianth obovoid or clavate, 1.1 mm. long, 0.6 mm. in diameter, slightly narrowed toward base and truncate above, beak obsolete, terete toward base, sharply five-keeled in upper part, the keels rounded above and narrowly, often obsoletely alate, whole surface of perianth roughened, due in the lower part almost entirely to convex cell-walls, in upper part to tubercles: ♂ inflorescence occupying a short branch or terminal on a leading branch; bracts in two to ten pairs, strongly inflated, unequally bifid, the lobe mostly rounded, the lobule subacute; bracteoles similar to the underleaves but smaller, found only at the base of the spike; antheridia in pairs: ripe sporophyte not seen (*pl. 22, f. 11–22*).

On bark of trees. North slope of the Luquillo Mountains, *Heller* (4745). El Yunque, *Evans* (189 *p.p.*). Originally collected by *Spruce*, in Brazil, and distributed in *Hepaticae Spruceanae.*

The presence of a subfloral innovation in *T. Aquarius* was originally looked upon as a somewhat aberrant character. Within recent years, however, several other species have been referred to *Trachylejeunea*, in which an innovation of this nature is of occasional or even of constant occurrence. There is little danger of confusing any of the other Puerto Rico Lejeuneae with this very distinct species. Its robust size and pale color, together with its avidity in absorbing water, recall perhaps certain species of *Hygrolejeunea* or *Taxilejeunea*, but its strongly tuberculate leaves and perianth and its large lobules with their peculiar apices, will at once separate it from both these genera. From the genera *Harpalejeunea* and *Strepsilejeunea*, to which it is really more closely allied, it may be distinguished by its large size and blunter leaves, as well as by other less apparent differences.

Even among the other *Trachylejeuneae* of tropical America, *T. Aquarius* has no very near relatives. The South American *Lejeunea* (*Trachy-Lej.*) *pellucidissima* Spruce * and *L.* (*Trachy-Lej.*) *pandurantha* Spruce * resemble it somewhat in size, color and general appearance, but both of these species are destitute of true subfloral innovations, and their leaf-cells, although more or less convex, are without tubercles and are either thin-walled throughout or have walls which are slightly and uniformly thickened.

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* Hep. Amaz. et And. 184. 1884.

Explanation of Plates

PLATE 20

Harpalejeunea subacuta Evans. 1. Part of plant with perianth, postical view, × 40. 2. Part of sterile stem, antical view, × 40. 3. Cells from middle of lobe, × 360. 4. Cells from antical margin of lobe, × 250. 5–7. Apices of lobes, × 250. 8. Base of lobe, showing ocelli, × 250. 9. Apex of lobule, × 250. 10. Underleaf, × 250. 11. Bracts and bracteole, × 40. The figures were all drawn from the type-specimens.

Harpalejeunea uncinata Steph. 12. Part of plant with ♀ inflorescence, postical view, × 40. 13. Part of sterile stem, antical view, × 40. 14. Perianth with involucre, postical view, × 40. 15. Cells from middle of lobe, × 360. 16. Cells from antical margin of lobe, × 250. 17. Apex of lobe, × 250. 18. Base of lobe, showing ocelli, × 250. 19. Outer portion of lobule, × 250. 20. Underleaf, × 250. 21. Bract and bracteole, × 40. 22. Bract, × 40. 23. Cells from margin of bract, × 250. 24. Cells from upper part of perianth-keel, × 250. The figures were all drawn from specimens collected by A. A. Heller (no. 4763).

PLATE 21

Harpalejeunea heterodonta Evans. 1. Part of stem with branch, postical view, × 35. 2. Branch, antical view, × 35. 3. Cells from middle of lobe, × 310. 4. Cells from antical margin of stem-leaf, × 220. 5. Tooth from antical margin of branch-leaf, × 220. 6. Apex of lobe, × 220. 7. Base of lobe, × 220. 8. Apex of lobule, × 220. 9. Underleaf, × 220. The figures were all drawn from the type-specimens.

Cyrtolejeunea holostipa (Spruce) Evans. 10. Part of stem with branch, antical view, × 55. 11. Part of stem, postical view, × 55. 12. Part of stem with perianth, postical view, × 55. 13. ♂ inflorescence, postical view, × 55. 14, 15. Cells from middle of lobe, showing variations in thickness of cell-wall, × 310. 16. Apex of lobe, × 310. 17. Base of lobe, × 310. 18, 19. Apices of lobules, showing variation in thickness of cell-wall, × 310. 20. Underleaf, × 310. 21. Apex of aberrant underleaf, × 310. 22. Bract, × 55. 23. Bracteole, × 55. Figs. 12, 13, 22 and 23, were drawn from specimens distributed by Spruce in *Hepaticae Spruceanae* (set belonging to the New York Botanical Garden); the remaining figures were drawn from specimens collected by the writer (nos. 21 and 46).

PLATE 22

Euosmolejeunea trifaria (Nees) Schiffn. 1. Leaf, antical view, × 35. 2. Cells from middle of lobe, × 310. 3. Same in cross-section, × 220. 4. Cells from antical margin of lobe, × 220. 5. Lobule, × 35. 6. Apex of lobule, × 220. 7. Underleaf, × 35. 8–10. Apices of divisions of underleaves, × 220. The figures were all drawn from specimens collected by the writer (no. 33).

Trachylejeunea Aquarius (Spruce) Evans. 11. Part of plant with ♂ branches and perianth, the subfloral innovation poorly developed, postical view, × 35. 12. Part of sterile branch, postical view, × 35. 13. Leaf, × 35. 14. Cells from middle of lobe, × 220. 15. Same in cross-section, × 220. 16. Cells from antical margin of lobe, × 220. 17. Basal part of lobe, showing three ocelli, × 220. 18. Apex of lobule, × 220. 19. Apex of one of the divisions of an underleaf, × 220. 20, 21. Bracts, × 35. 22. Bracteole, × 35. The figures were all drawn from specimens collected by A. A. Heller (no. 4745).

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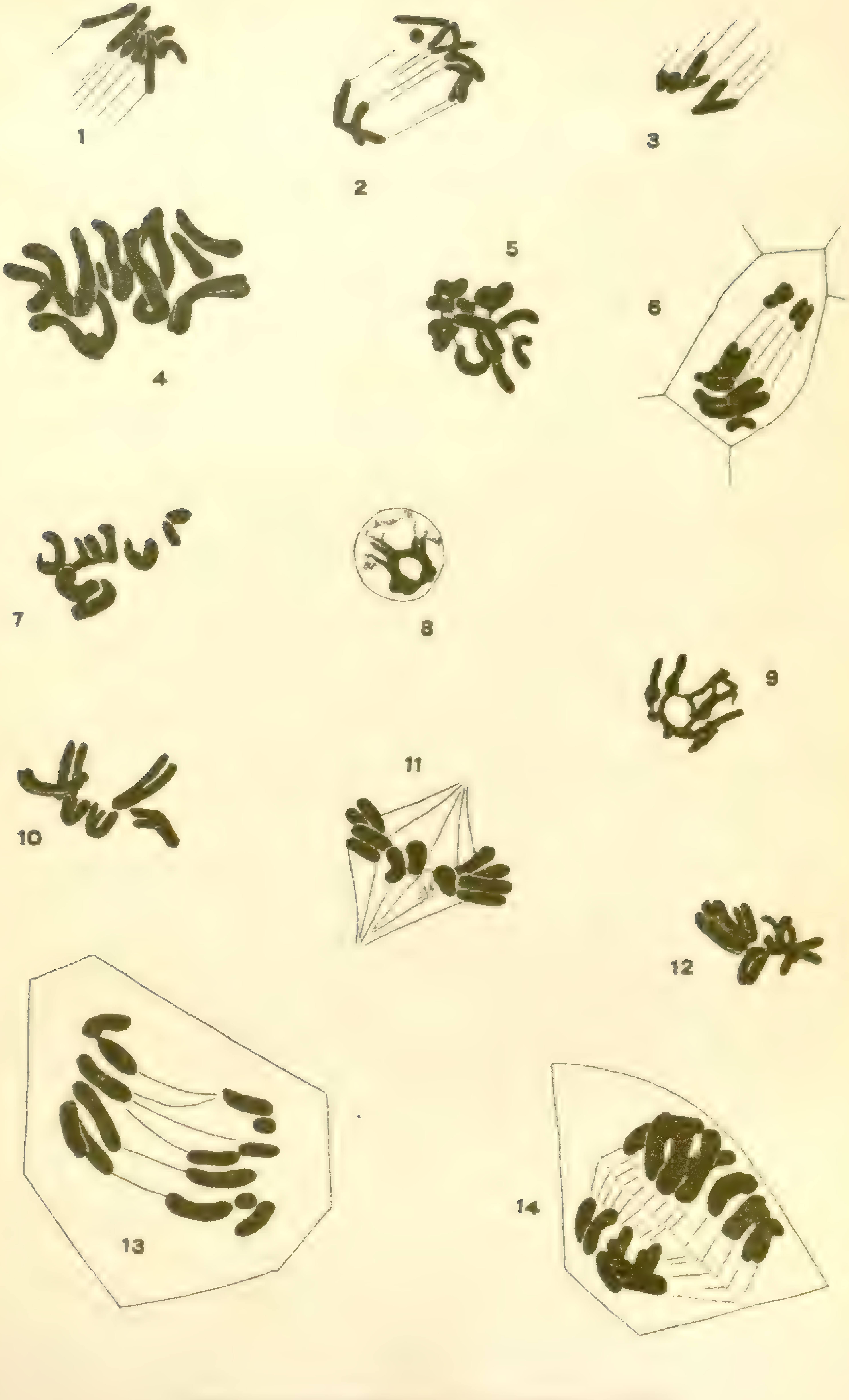
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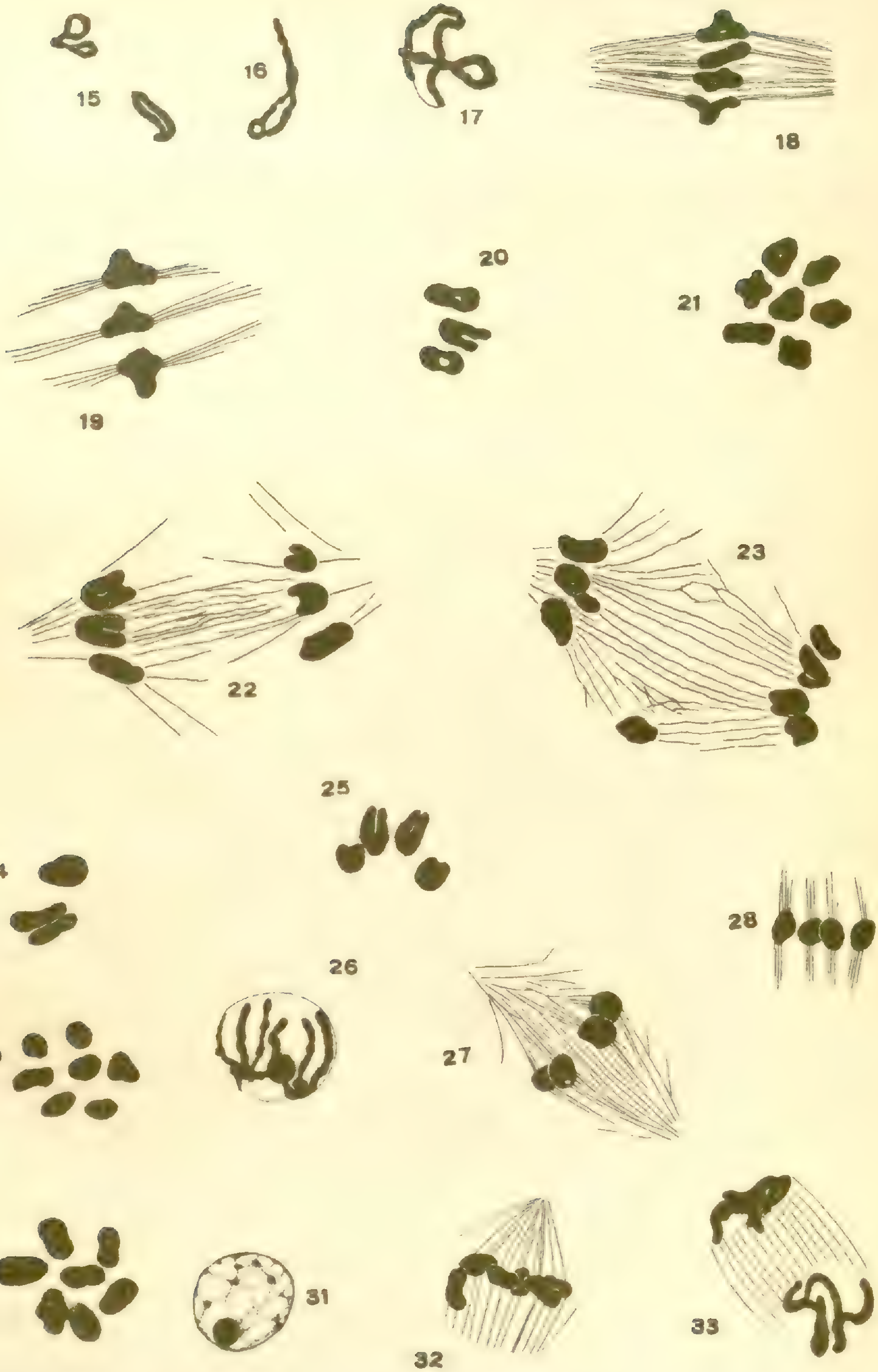
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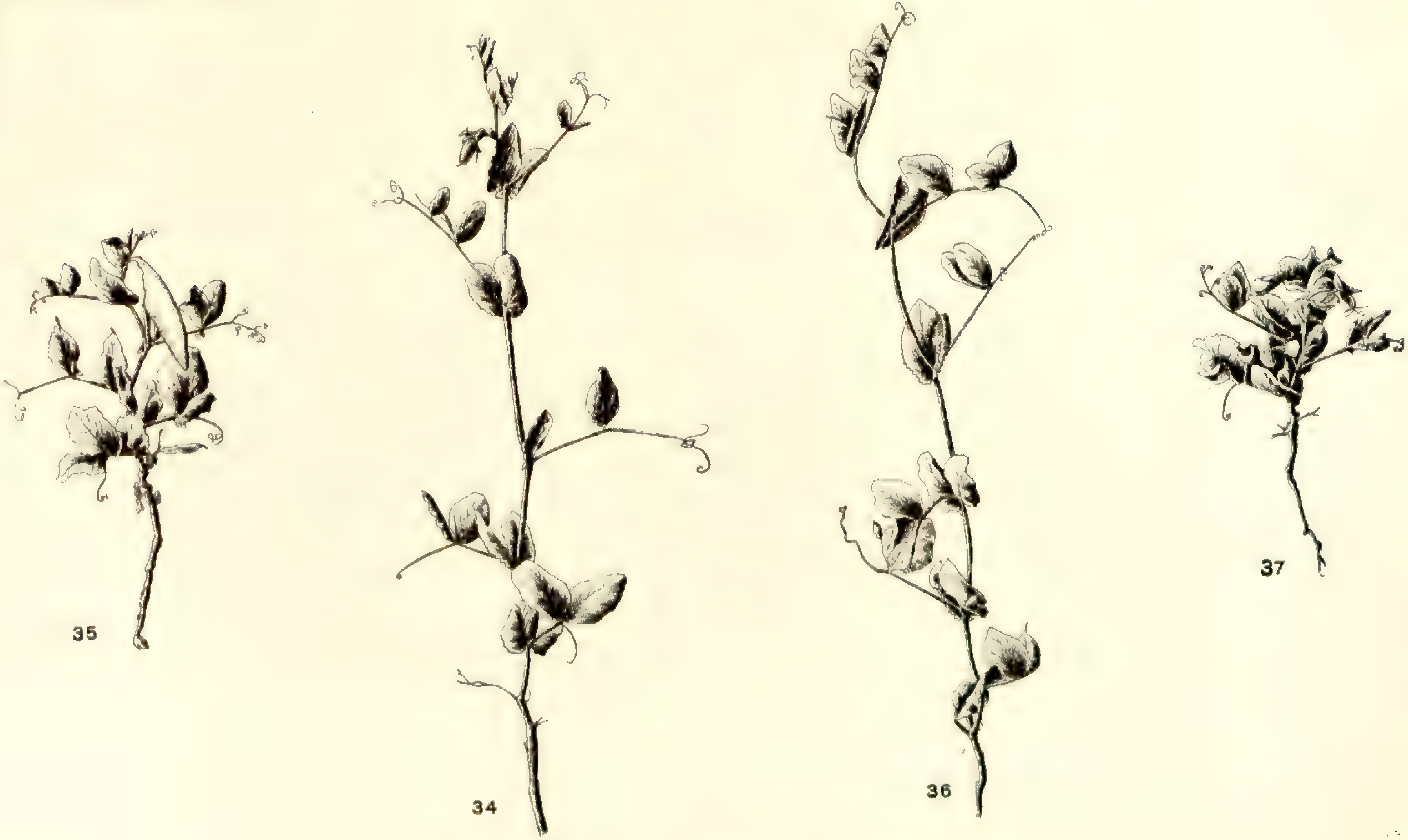

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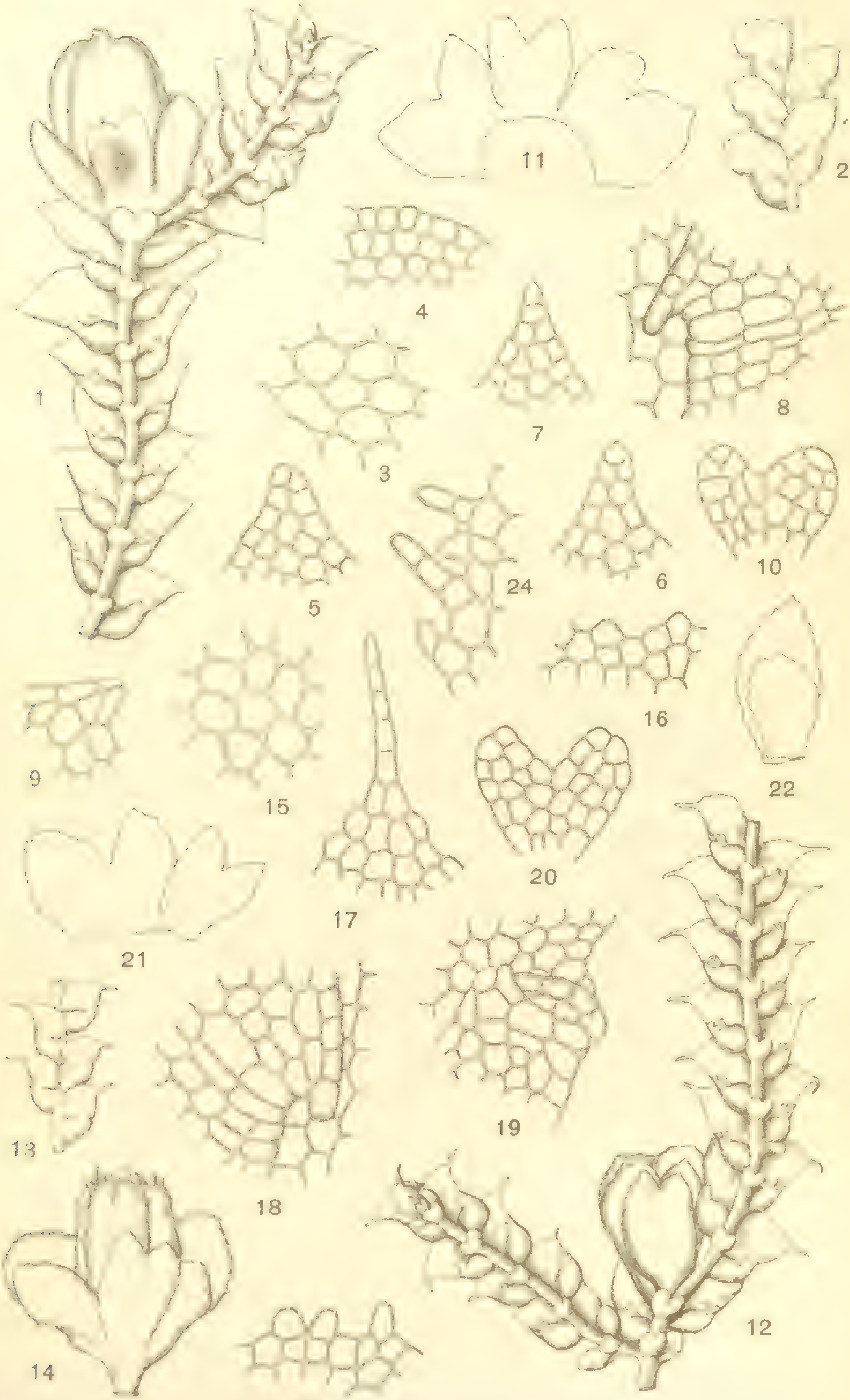
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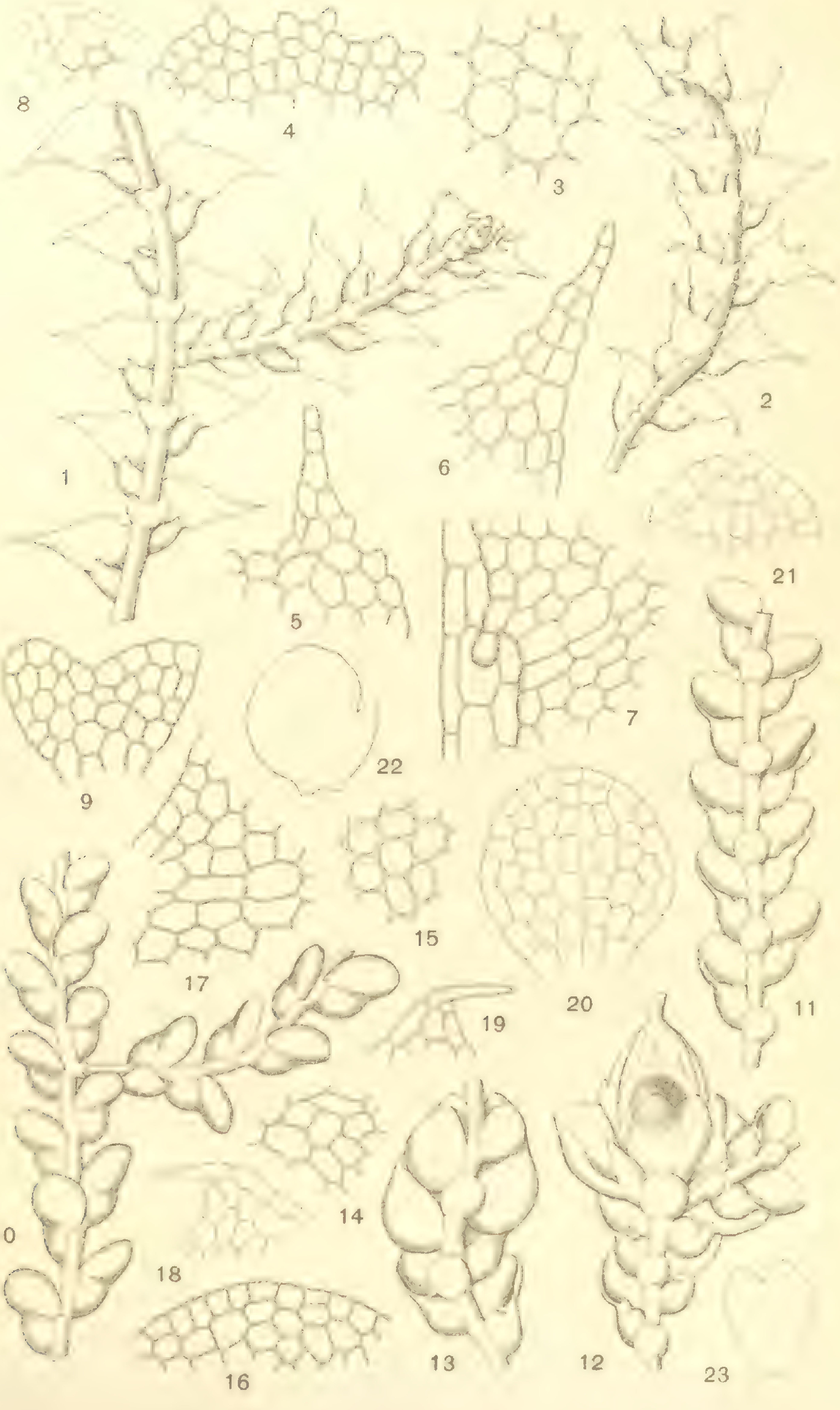
1-11. HARPALEJEUNEA SUBACUTA Evans.

12-24. HARPALEJEUNEA UNCINATA Steph.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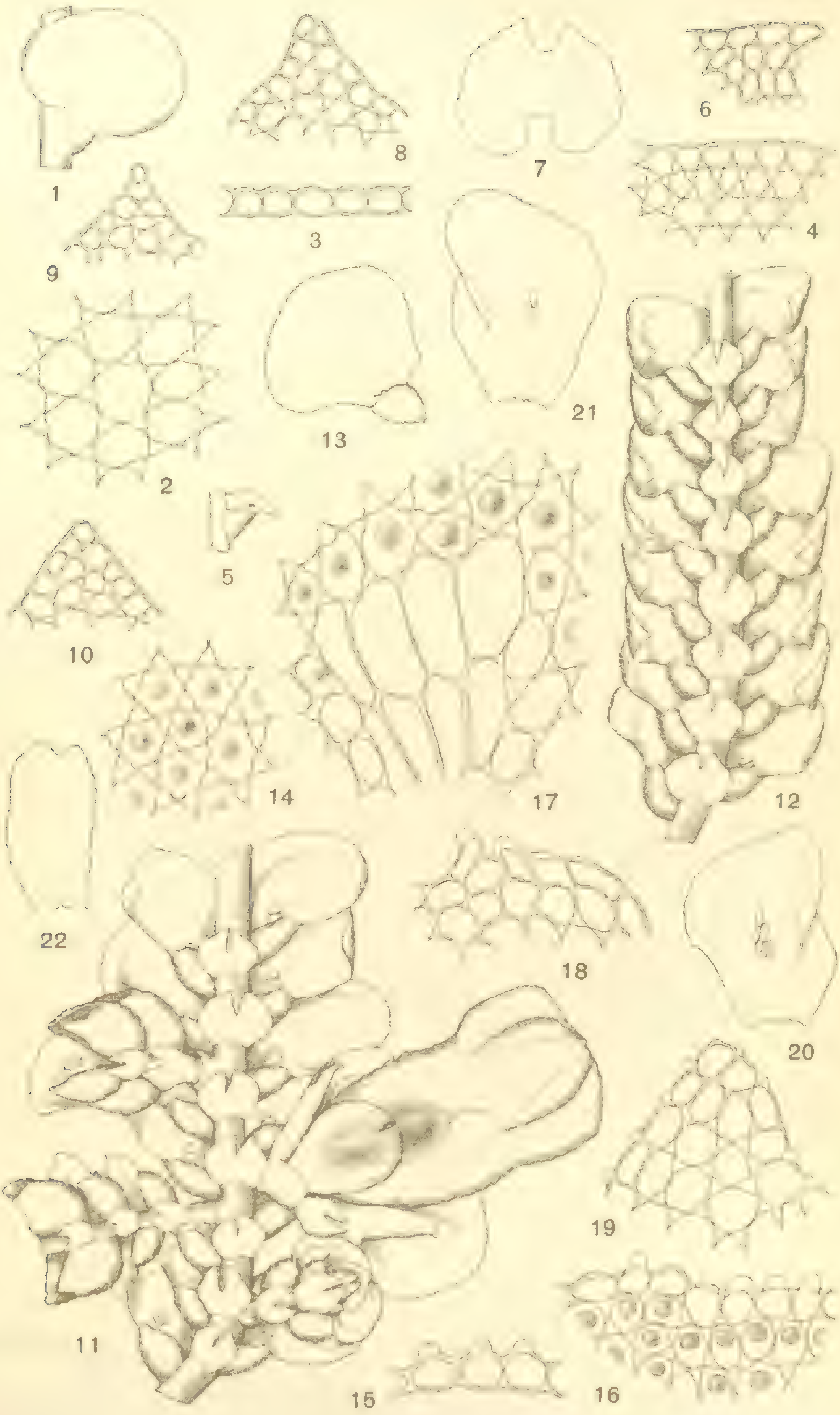
1-9. HARPALEJEUNEA HETERODONTA Evans.

10-23. CYRTOLEJEUNEA HOLOSTIPA (Spruce) Evans.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1-10. EUOSMOLEJEUNEA TRIFARIA (Nees) Schiffn.

11-22. TRACHYLEJEUNEA AQUARIUS (Spruce) Evans.

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OF THE

TORREY BOTANICAL CLUB

NOVEMBER, 1903

Vegetation of the North Haven Sand Plains

BY WILTON EVERETT BRITTON

(WITH PLATES 23-28)

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PART I: PHYSIOGRAPHY AND VEGETATION

BRIEF DESCRIPTION OF THE REGION

Stretching northward along the east side of the Quinnipiac River valley for fifteen or sixteen miles, almost the entire distance from New Haven to Meriden, Connecticut, is a narrow sand plain or series of sand plains. Though perhaps once continuous, the area is now crossed by small streams which have cut their channels through the sand. In some instances alluvium has been formed along the beds of these streams supporting a somewhat different class of plants than is found on the plains. In this way the area is divided transversely into a number of small plains.

[The preceding number of the BULLETIN, Vol. 30, No. 10, for October, 1903 (30: 519-570, *pl. 17-22*) was issued 5 O 1903.]

A large portion of this land has been improved, is now cultivated and produces fair agricultural crops. Some of the factories of Wallingford are built upon this land, as are also portions of the villages of North Haven and Montowese. Many acres, however, may be called waste land and are covered only with red cedars and *Andropogon scoparius.* The Hartford division of the New York, New Haven and Hartford railroad crosses this area longitudinally from North Haven to its northern extremity near Meriden, and the Air Line division of the same railroad crosses the southern end obliquely at Montowese.

Over nearly the entire region we find here and there certain small tracts, resembling miniature deserts, where the conditions have not been favorable for plant growth and which are quite barren. Why should such small areas remain still practically uncovered by vegetation? The answer must be found in the unfavorable character of the soil, which will later be described briefly in this paper. In the opinion of the writer, a much greater portion of the sand plains was formerly barren, and two facts support this opinion: (1) There are no evidences that the plains were ever covered with forest growth; no large trees remain and, if such had ever existed and were removed, there would be sprouts or stumps to tell the story, for stumps do not decay rapidly in such a soil. (2) The areas are now being gradually covered through the agency of certain plants that are able to grow under the conditions that prevail upon these sand plains.*

The present paper is an account of observations on the flora of these barren areas, and of the result of examinations of the structure of certain of these plants to ascertain if they show any special adaptations that enable them better to meet the conditions found in such situations. For the purpose of the investigation two barren areas were chosen because they were among the largest of these sterile tracts, and more accessible to the writer than were the other similar areas. One of these is an irregular-shaped area of perhaps eighty or ninety acres situated a short distance north of the village of North Haven, and is the region that will be referred to as the North Haven tract. A smaller area containing nearly forty acres, near the Montowese station of the Air Line division of the New York, New Haven and Hartford railroad, was also studied and will be designated the Montowese tract.

---

* Since this was written, the writer has been assured that the barren areas were formerly much larger and are being gradually covered by vegetation.

These tracts are about three miles apart, being separated by land of similar formation and character which has been improved and is now used for tillage and for pasture. The Montowese tract is bordered on the west by the Quinnipiac River, but is several feet higher than the water in the river. The topographical lines on the map of this region prepared by the United States Geological Survey show the Montowese tract to be about twenty feet above sea-level and the North Haven tract to be not far from forty feet.

The writer had often noticed these sand barrens from railway trains and first in May, 1899, was able to reach them for a day's collecting. In the spring of 1901 it was decided to make a somewhat systematic study of the plants of this region and from April to October of this and the following year (1902) each tract was visited about once in two weeks and the flowering plants collected and field notes made about the flora of the region. Specimens were pressed and mounted, and the roots of many species were preserved in formaldehyde solution for histological study.

It must not be inferred that the boundaries of these areas are naturally well-defined, for except where the river washes away the sand from the Montowese tract the soil-formation is much the same without as within the boundaries of the areas. But it is more densely covered with vegetation, though producing the same species of plants, showing that in some respects at least, the conditions must have been more favorable for plant growth than on the barren areas. In fact these areas may fairly be regarded as the least favorable, as they are the last to be covered with vegetation.

Winds and water have changed slightly the topography of both tracts, but as they are not particularly exposed, the winds do not have a very long sweep and the shifting of the sand is not rapid. That it exists, however, observation is the only proof required. Some of the trees have their roots laid bare by the winds, where the ground is so nearly level as wholly to preclude the idea of washing (see *pl. 25, b*). A board fence along the west side of the railroad track at Montowese (also shown in *pl. 25, b*), constructed for the purpose of keeping either sand or snow from blowing upon the tracks, is banked on its west side by a sand drift of half its height. Here the west winds are chiefly instrumental in the shifting, and on the bank of the river much of the finer sand has been removed by it. Slight shifting by winds also occurs on the North Haven tract. Heavy showers, upon the sand where the ground is not perfectly level, cause temporary erosion, by the surface water on its way to lower levels washing away the sand in its path. At Montowese such water goes into the river, but the preparation of the railroad-bed across the North Haven tract necessitated some cutting and filling and excavations were made in the sand for filling material. These excavations give the surface waters a chance to reach a lower level and channels are cut in the sand. In a clay formation such channels are deep with steep banks but in loose sand they are very shallow with widely sloping banks because the soil particles will not hold together. On the banks the winds also strike with greater force than on the level and several trees are left with exposed roots from the combined effect of winds and washing away of the sand (see *pl. 25, c*).

SOIL AND MOISTURE

It has already been mentioned that edaphic factors (*i. e.*, soil conditions) are chiefly responsible for the barren state of these areas. The soil is mostly sand of medium fineness, or gravel containing pebbles, an inch or so in diameter in some places, of which broken red sandstone forms a part. This formation is called drift and is of glacial origin. It is probably the deposit of the water from the melting glacier and not the moraine. No chemical analyses were made to determine the fertility of the soil of these desert regions, but during the seasons of 1898 and 1899 the Connecticut Agricultural Experiment Station conducted some experiments with forage plants near the Montowese railroad station only a short distance from the barren area. The ground used in the tests had formerly been cultivated, but was neglected for many years, and the soil contained only .09 of one per cent. of nitrogen. It is probable that this soil also has small quantities of phosphoric acid and potash as is the case with other similar soils. But as leguminous plants are able to obtain nitrogen from the air, these might be expected to grow here, were a lack of soil fertility the only handicap. What seems to be a more important factor is the almost total absence of humus or organic matter. Whitford records the existence of similar conditions on the sand beaches of northern Michigan,* and observes that such a soil is favorable for the development of creeping stems and rhizomes.

Though the sand appears to be dry at the surface I have always found plenty of moisture a few inches below the surface, even in a protracted drought. The explanation may be found, perhaps, in the low altitude of the region and its proximity to tide-water. The North Haven tract is only about forty feet above tide-water and less than three miles from it, as the tide sets back quite a distance from the mouth of the Quinnipiac River. The Montowese tract is less than twenty feet above the tide-water, which reaches to its very edge. The mechanical condition of the soil enables the moisture to rise quite rapidly to the surface, from a considerable depth, through capillarity.

In order to obtain water for the forage experiments just mentioned a well was driven fifteen feet deep, and the pipe contained water to the height of four feet from the bottom. The well was upon ground higher than the barren area. A considerable excavation has been made beside the railroad a short distance north of the North Haven tract and water stands in this excavation except in a very dry time.

Evaporation must be very great from such a soil and the continual drying up of the surface together with the intense heat on sunny days is probably the excuse for the scanty vegetation of the region. Thousands of seedlings must perish each season by drying up before the roots gain a sufficient depth to provide the necessary moisture. In several cases heavy wagons had crossed the sand and the sunken tracks were filled with young seedlings of *Trichostema dichotomum*. These seedlings had grown so much larger and closer together than those outside the tracks, that they could be seen for some distance as green lines or ribbons stretched across the plains. The sand was here compressed two or three inches below the surrounding level and the germinating seeds found a more abundant moisture supply as well as a firmer foothold. Doubtless many of the seeds were blown into the furrows. Annual plants must usually mature before the hot days of July and August or they perish without perpetuating the species.

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* Whitford, H. N. Genetic development of the forests of northern Michigan; a study in physiographic ecology. Bot. Gaz. 31: 289–325, *f. 1–18*. 1901. (Page 298.)

No records were made of the temperature of the soil or of the atmosphere near the soil, but unquestionably both would be several degrees higher near the surface than where the soil is covered with turf, or where the soil is of a different character.

The rainfall on these areas is probably not very different from the official record of the Weather Bureau at New Haven. The record of the rainfall as well as the temperature by months for the two years during which these studies were made is here given:

Precipitation

	1901	1902
January,	1.38 inches.	1.83 inches.
February,	.54 "	3.58 "
March,	5.80 "	4.63 "
April,	9.03 "	3.40 "
May,	6.38 "	1.61 "
June,	.25 "	4.35 "
July,	4.40 "	3.26 "
August,	6.92 "	2.14 "
September,	5.70 "	5.84 "
October,	2.95 "	6.41 "
November,	1.61 "	.79 "
December,	7.65 "	6.49 "
Total,	52.61 inches.	44.33 inches.

Temperature

		1901			1902	
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January,	28	49	— 1	27	49	6
February,	24	41	8	27	50	11
March,	36	52	9	42	65	22
April,	47	69	35	47	80	32
May,	55	80	39	57	85	36
June,	68	94	47	64	89	47
July,	74	97	53	69	90	53
August,	72	86	56	68	87	52
September,	64	87	41	63	84	45
October,	53	76	31	53	74	31
November,	37	60	12	46	67	26
December,	31	59	5	28	53	— 5
	49	97	— 1	49	90	— 5

During 1901 annual vegetation was scarce on the sand plains, but it was much more abundant during 1902. The only explanation can be found by looking up the record of rainfall for June, which in 1901 was only .25 inch, while in 1902 it was 4.35 inches. More rain fell in May and July of 1901 than came in the corresponding months of 1902, but June is the month when most annuals appear on the plains and the amount of rainfall for that month is therefore a criterion of the abundance of annual plants for the season.

VEGETATION

The chief forms of vegetation of this region are essentially xerophytic in character, though the conditions under which they are produced may not be strictly xerophytic. No great lack of moisture exists, but the burning heat of the sun on the sand enables only xerophytes to persist; other plants perish soon after the seeds germinate.

Andropogon scoparius grows in tufts on both the North Haven and Montowese tracts (see *pl. 23*, *a*) and is probably the most abundant of all the perennial grasses. A single patch of *Andropogon furcatus* occurs at North Haven. This plant has thickened root nodes (see *pl. 27*, *e*) in which food and moisture are stored up and carried through the winter. On both tracts *Cyperus filiculmis* is the most common sedge, and the dead and dried tubers may be seen partly uncovered in many places where the plants have been killed through fire or some other agency. In the clumps of trees *Poa compressa* is found sparingly. During 1902 an annual grass came up very abundantly on the sand at Montowese during the latter part of June and was probably the most abundant annual of the region, forming a thick carpet in many places. This proved to be *Sporobolus vaginaeflorus*, and in company with it occurred *Syntherisma sanguinalis* and *S. filiformis*, both being annuals. Other common annuals growing here were blue curls (*Trichostema dichotomum*), which was the most abundant annual plant on the North Haven tract, and *Polygonella articulata* common to both areas. *Sarothra gentianoides* (*Hypericum nudicaule*) was common at North Haven, where during both seasons this little plant formed green patches upon the sand (see *pl. 25*, *a*). Among the perennial herbaceous dicotyledonous plants the milkweeds (*Asclepias Syriaca, A. amplexicaulis* and *A. verticillata*), *Lespedeza*, *Baptisia tinctoria*, *Meibomia*, *Helianthemum majus* and *Artemisia caudata* predominate. *Rubus procumbens* (*R. Canadensis* of authors) is also abundant, covering the ground in many places. At North Haven it grows in the grass (*Andropogon scoparius*) around the boundaries of the barren area, but at Montowese it grows and fruits heavily on the bare sand. The red cedar (*Juniperus Virginiana*) is the most common conifer of the region, though *J. communis* occurs frequently and a notably large specimen growing at Montowese is about thirty feet in diameter.

Many black cherry trees (*Prunus serotina*) are found around the margins of the Montowese tract, and there are several sassafras trees. The latter have a tendency to form colonies by sprouting from the roots. The common milkweed (*Asclepias Syriaca*) also occurs in colonies, one of which is shown on *pl. 24, b.* *Baptisia tinctoria* is abundant at Montowese and is shown on *pl. 23, b.*

A peculiar feature of the sand plains is the total absence of cruciferous plants. Certain species like *Lepidium Virginicum* and *Bursa Bursa-pastoris* are commonly found in similar places. No cruciferous plants were found on either tract during the two seasons that plants were collected. Then, too, certain plants of the pink family (Caryophyllaceae) like *Arenaria* and *Tissa* and the chickweeds might fairly be expected to grow in such places. The pink family is represented only by soapwort or bouncing bet (*Saponaria officinalis*), which occurs on the North Haven tract.

One very interesting feature of that portion of the North Haven tract lying west of the railroad, is the presence of numerous scrubby black oaks (*Quercus velutina* = *Q. coccinea tinctoria*) scattered about over the region (*pl. 24, a*). Two questions suggest themselves simultaneously — (1) Why does the black oak grow here instead of other trees? (2) Why are the oaks so scattered instead of occurring in groups? From a careful study it seems to the writer that the acorns which produced these trees must have been buried in the sand either by squirrels or by some other agency, for those that now fall upon the surface of the ground each year from the parent trees never making seedlings. At least, probably not one in a thousand ever does. They fall upon the sand under the trees, probably germinate and dry up before the radicles can reach a sufficient depth to obtain the necessary moisture. In some unpublished investigations Professor J. W. Toumey has found that in hard soil the radicle is not able to work its way into the soil, but on account of the lightness of the acorn it is tumbled about on the surface. The shells form a coating on the sand under the oaks, and with fallen leaves and other waste vegetable matter that is blown about, help to form a thin layer of leaf-mold where not destroyed by fire.

Under these oaks grows a moss, *Polytrichum piliferum*, which also aids in the formation of soil. The rhizoids hold together the upper two inches of sand, thus preventing it from shifting, and the plant doubtless has some influence on the retention of the moisture. Therefore certain plants grow in company with the moss which do not appear on other portions of the sand area and which probably could not persist there. The scrub-oak (*Quercus nana*) also grows at North Haven and there are several specimens of dwarfed chestnut trees.

Certain areas on the North Haven tract are covered with reindeer moss, *Cladonia rangiferina*, and where this lichen becomes established other plants soon spring up. It holds the sand from shifting, and leaves and other portions of plants blown about by the winds finally lodge upon it creating a thin layer of slowly decaying vegetable matter. The surface being undisturbed and the leaf-mold retaining a portion of the moisture that formerly escaped through evaporation, seeds that fall upon this area are able to germinate and grow. Sweet fern (*Comptonia peregrina*) covers quite an area near the reindeer moss and may perhaps follow it as the next stage in the development of a forest growth on this land.

Much of the accumulating humus on the North Haven tract has been destroyed by fires probably started by sparks emitted from passing engines. Leaves and dry grass have been burned in this manner and in one locality the sedges collected show the result of such fires; the old culms had been burned off level with the sand and from the blackened base the new growth had been pushed out. Fires cannot sweep over the whole area for lack of combustible material, yet the dry leaves which have lodged between the stems of grasses and other plants covering small areas here and there are frequently burned off in this manner, thus destroying small quantities of what is most needed to make this a plant-producing soil — humus, or organic matter.

Though certain species of plants must necessarily remain constant in this region, the flora doubtless changes somewhat from year to year, and if these studies should be continued several new plants would probably be found, while some of the plants collected might disappear.

A feature to be noted is the presence of several plants commonly found in swampy regions. *Rhus radicans* forms large masses of foliage at North Haven and though common throughout Connecticut, grows often in swamps in northern New England. *Nyssa sylvatica* and willows are swamp trees, and *Spartina cynosuroides* is common to the brackish marshes of the coast * *Aronia* (or *Pyrus*) *arbutifolia* is a denizen of wet places as are *Vaccinium corymbosum* and *Kalmia angustifolia*, all growing in shallow water in many swamps. *Ilex verticillata* is also an inhabitant of damp ground. *Stenophyllus* (or *Fimbristylis*) *capillaris* and *Rosa Carolina* are also found in moist places.

Following is a list of the chief plants of the region collected during 1901 and 1902, with the exception of a few specimens gathered in 1899. All were found growing within the limits of the regions, except *Lupinus perennis*, which grows in large areas a short distance north of the North Haven tract, and *Cracca Virginiana*, which covers quite a plot of ground a few rods southwest of the Montowese tract. The latter is also a common inhabitant of the sand plains through Wallingford and is found just north of the limits of the North Haven tract. These two plants have been included because they are important plants for the region and occur on the same formation and under practically the same conditions, though not actually found growing within the arbitrary limits of our tracts.

The nomenclature is that used in Britton's Manual, the name used in Gray's Manual, sixth edition, being cited in parentheses when different.

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* Winton, A. L. Forage plants of the salt marshes of Connecticut. Conn. Agric. Exp. Sta. Ann. Rep. **1889** : 233–245. 1890.

LIST OF THE MORE IMPORTANT PLANTS

In all 135 species of plants were collected on the sand plains in 1901 and 1902. Many of these were rare and of no importance in covering the sand. The species here given are some of the more abundant ones :

Juniperus communis L. Frequent, occurring on both tracts.

Juniperus Virginiana L. Common at both North Haven and Montowese, the most abundant of all Coniferae.

Andropogon scoparius Michx. The most common perennial grass of the plains, forming tufts. Grows at both North Haven and Montowese, and is to be considered an important factor in covering the soil.

Andropogon furcatus Muhl. A single patch several feet in diameter grows at North Haven east of railroad. This species is larger than the preceding and spreads by rootstocks.

Syntherisma sanguinalis (L.) Dulac. (*Panicum sanguinale.*) Frequent at Montowese.

Panicum depauperatum Muhl. Occasional at North Haven, forming low tufts on the sand.

Sporobolus vaginaeflorus (Torr.) Wood. Extremely abundant at Montowese in 1902, much less so in 1901. Grows very quickly.

Spartina cynosuroides (L.) Willd. Occasional in several places on bank of Quinnipiac River at Montowese.

Poa compressa L. Frequent, especially around trees at North Haven and Montowese.

Cyperus filiculmis Vahl. The most common sedge at both places, growing in loose tufts on the sand.

Stenophyllus capillaris (L.) Britton. (*Fimbristylis capillaris.*) Frequent at both places.

Carex Pennsylvanica Lam. Occurs west of railroad, near ravine, North Haven tract.

Carex Muhlenbergii Schk. Occasional at both places.

Populus grandidentata Michx. Frequent at North Haven and Montowese.

Comptonia peregrina (L.) Coulter. (*Myrica asplenifolia.*) Common, forming large patches at North Haven.

Betula lenta L. Frequent, North Haven tract.

Betula populifolia Marsh. Common.

Castanea dentata (Marsh.) Borkh. (*C. sativa Americana.*) Common in both places.

Quercus velutina Lam. (*Q. coccinea tinctoria.*) The commonest tree on the North Haven area, and is common at Montowese.

Quercus palustris Du Roi. Frequent at North Haven and Montowese.

Quercus nana (Marsh.) Sarg. (*Q. ilicifolia.*) Occasional. Several plants at North Haven.

Rumex Acetosella L. Common on both areas.

Polygonum Convolvulus L. Rare. Occurs at North Haven.

Polygonella articulata (L.) Meisn. Common in late summer at North Haven and Montowese.

Liriodendron Tulipifera L. Three or four trees occur east of railroad at North Haven.

Thalictrum purpurascens L. Frequent on edge of Montowese tract.

Berberis vulgaris L. Occasional.

Sassafras Sassafras (L.) Karst. (*S. officinale.*) Frequent at North Haven and Montowese. At Montowese several large trees have sprouted from the roots, forming groups of small trees.

Platanus occidentalis L. A few trees at North Haven.

Amelanchier Canadensis (L.) Medic. Frequent, several dwarfed specimens at North Haven.

Rubus procumbens Muhl. (*R. Canadensis* of Gray's Manual.) Common on both areas, and covers the ground in places; grows with *Andropogon scoparius.*

Fragaria Virginiana Duchesne. Common on both tracts.

Potentilla Canadensis L. Common.

Prunus Virginiana L. Occurs at North Haven.

Prunus serotina Ehrh. Common in both places.

Baptisia tinctoria (L.) R. Br. Common. The most common perennial legume at Montowese (see *pl. 23, b*). Rather rare at North Haven on the barren area, but occurs around it and farther north.

Crotalaria sagittalis L. Frequent, growing along the sides of the railroad, in company with *Strophostyles helvola.*

Lupinus perennis L. Does not occur within the limits of either the North Haven or Montowese tracts, but grows in abundance in fields northeast of the former, covering many square rods. Also occurs northeast of the Montowese barren area.

Cracca Virginiana L. (*Tephrosia Virginiana.*) Like *Lupinus perennis*, this plant does not belong strictly within the limits of our area, but grows in great abundance just south and west of the Montowese plain. It is also common north of the area studied at North Haven and is a very important plant for such regions.

Robinia Pseudacacia L. Common at North Haven where there are several medium-sized trees.

Meibomia Dillenii (Darl.) Kuntze. (*Desmodium Dillenii.*) Frequent. Grows near railroad at North Haven.

Meibomia Canadensis (L.) Kuntze. (*Desmodium Canadense.*) Common, both at North Haven and at Montowese.

Lespedeza capitata Michx. Common on both areas.

Strophostyles helvola (L.) Brittón. (*S. angulosa.*) Common at both places along the railroad tracks.

Euphorbia polygonifolia L. Occasional at Montowese near river.

Rhus radicans L. Common in both places forming dense, low, foliage masses and covering the ground around the bases of trees. An important xerophyte.

Rhus glabra L. Frequent.

Rhus hirta (L.) Sudw. (*R. typhina.*) Occurs at Montowese near the railroad.

Rhus copallina L. Frequent both at North Haven and at Montowese, growing in the sand with *Rubus procumbens.*

Celastrus scandens L. Common both at North Haven and at Montowese, occurring usually in groups of trees or plants.

Sarothra gentianoides L. (*Hypericum nudicaule.*) Abundant at North Haven, where it formed a carpet over several large areas of sand during midsummer (see *pl. 25, a*). Much more abundant in 1902 than in 1901, probably on account of moisture.

Helianthemum majus (L.) B.S.P. Common on the sand at both places, fruiting heavily.

Viola sagittata Ait. and *Viola pedata* L. Frequent, both at Montowese and at North Haven, the roots being buried deep in the sand in many cases.

Nyssa sylvatica Marsh. Occurs at North Haven east of railroad.

Azalea nudiflora L. (*Rhododendron nudiflorum.*) Two plants stand alone in the sand west of railroad near north end of New Haven tract.

Kalmia angustifolia L. Occurs near north end of North Haven tract west of railroad, around the outside of a clump of bushes.

Gaylussacia resinosa (Ait.) Torr. & Gray. Occurs near north end, west of railroad, North Haven tract.

Vaccinium corymbosum L. Several large plants west of railroad, north end of North Haven tract.

Lysimachia quadrifolia L. Frequent on both areas growing around or in shade of the clumps of trees.

Asclepias Syriaca L. (*A. Cornuti.*) Common, especially at Montowese where it grows in colonies. A colony on a mound is shown on *pl. 24, b.* Roots run very deep.

Asclepias amplexicaulis J. E. Smith. (*A. obtusifolia.*) Common on both areas where it is deep-rooted in the sand.

Asclepias verticillata L. The most abundant milkweed of the sand plains, generally growing with grass or weeds, seldom in the open sand.

Trichostema dichotomum L. Common. One of the few annuals abundant on both tracts. Plants usually very small and some even killed before maturing. More abundant in 1902 than in 1901.

Verbascum Thapsus L. Occasional at North Haven.

Linaria Canadensis (L.) Dumont. Common all over the North Haven area. In grass around the barren tract, the ground was blue with the flowers on June 8, 1901.

Linaria Linaria (L.) Karst. (*L. vulgaris.*) Frequent at North Haven.

Chrysopsis falcata (Pursh) Ell. Occurs at south end of North Haven tract west of railroad.

Solidago nemoralis Ait. Frequent.

Ionactis linariifolius (L.) Greene. (*Aster linariifolius.*) Frequent around clumps of trees east of railroad at North Haven.

Leptilon Canadense (L.) Britton. (*Erigeron Canadensis.*) Common in both places.

Erigeron ramosus (Walt.) B.S.P. (*E. strigosus.*) Frequent.

Ambrosia artemisiaefolia L. Common ; small plants found on both tracts

Achillea Millefolium L. Frequent.

Chrysanthemum Leucanthemum L. Frequent.

Artemisia caudata Michx. Common, especially at North Haven, where it grows with *Rubus procumbens* and *Andropogon scoparius*.

PART II: STRUCTURE OF PLANTS EXAMINED

Considerable attention has been given to the structure of the leaves and stems of plants, for it is in them that the most striking modifications have taken place to prevent a loss of moisture through transpiration. The plants of the Arabian desert, between the lower Nile and the Red Sea, have been studied by Volkens, who has published an elaborate work* on this subject in its ecological relations. Schimper figures the structure of certain leaves and stems in his Pflanzen-geographie.† More recently Kearney has recorded the anatomy of the leaves of some of the plants of the North Carolina strand ‡ and explained the ecological significance of the structures. This line of research is carried still farther by the same author in his report on a botanical survey of the Dismal Swamp region.§ In 1899 Mr. Thomas A. O'Brien in manuscript interpreted the structure of *Spartina cynosuroides*, *Carex Muhlenbergii*, *Cyperus filiculmis* and *Poa compressa*.¶ But little attention has been paid to the root structures of plants in relation to environment. The roots of many grasses and sedges have been studied by Mr. Theodor Holm, who has published a number of papers in the Botanical Gazette * and in the American Journal of Science,† but while the author points out the probable uses of certain structures they are not considered from the ecologist's standpoint.

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* Volkens, G. Die Flora der aegyptisch-arabischen Wüste. 156 pp. *18 pl.* Berlin, 1887.

† Schimper, A. F. W. Pflanzen-geographie auf physiologischer Grundlage. 876 pp. *502 f.* + *4 maps.* Jena, 1898.

‡ Kearney, T. H. The plant covering of Ocracoke Island : a study in the ecology of the North Carolina strand vegetation. Contr. U. S. Nat. Herb. **5** : 261–319, *f. 38–50.* 1900.

§ Kearney, T. H. Report on a botanical survey of the Dismal Swamp region. Contr. U. S. Nat. Herb. **5** : 321–550, *pl. 66–76* + *f. 51–85.* 1901.

¶ O'Brien, T. A. The ecological structure of four native xerophytes. Manuscript presented as a graduating thesis, Sheffield Scientific School of Yale University, 1899.

The present writer has examined the roots of a number of plants found growing upon the sand plains for the purpose of ascertaining to what extent the subterranean parts of the plants become especially adapted for taking up and holding moisture. Any corresponding adaptations of leaves and stems which have come to his notice are considered in the present paper.

A microscopic study has therefore been made of the leaves of twenty-three species, the stems of three, the roots of thirty-five, and the rhizomes of seven.

HISTOLOGY OF LEAVES AND STEMS

The material examined was collected on the sand plains. Leaves of several species were preserved in formaldehyde solution, but in some instances it was necessary to examine dried material which was first soaked in potash-water. All sections were cut by hand.

POLYTRICHUM PILIFERUM. — The central portion of the leaf is more than a single layer of cells in thickness, while the edges of the leaf are formed of a single layer and are rolled upward at the base. The thickened portion bears near the base of the leaf a large number of lamellae. The edges of the leaf roll in such a manner as to cover the lamellae, forming an excellent hindrance to the loss of moisture. The lamellae are doubtless capable of absorbing much water and are not greatly injured if they become dry.

SYNTHERISMA SANGUINALIS. — About four layers of large water-cells are found over the keel, forming more than half the thickness of the leaf (see *pl. 26*, *e*). The entire epidermal layer is of similar colorless cells and forms about one third of the thickness of the leaf.

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* Holm, T. A study of some anatomical characters of North American Gramineae. Bot. Gaz. **16**: 166–171, *pl. 15*. 219–225, *pl. 21*, *22*. 275–281, *pl. 23*, *24*. 1891; **17**: 358–362, *pl. 21*. 1892; **20**: 362–365, *pl. 26*. 1895; **21**: 357–360, *pl. 27*, *28*. 1896; **22**: 403–406, *pl. 20*. 1896.

† Holm, T. Studies in the Cyperaceae. Am. Jour. Sci. IV. **3**: 121–128, *pl. 4*. 1897; **4**: 13–26, *f. 1–19*. 298–305, *f. 1–4*. 1897; **7**: 171–183, *f. 1–9*. 435–450, *f. 1–14*. 1899; **9**: 355–363, *f. 1*, *2*. 1900; **10**: 33–47, *f. i–iii*. 266–284. 1900; **11**: 205–223, *f. 1–3*. 1901; **14**: 57–63, *f. 1–7*. 417–425, *f. 1–11*. 1902.

The lower epidermis is made up of smaller colorless cells. The cells are much enlarged locally around the bases of long, simple unicellular hairs; subepidermal strands of stereome occur on the upper surface as follows: On the outside of the water-holding tissue over the keel and above eight of the largest mestome bundles. Similar strands are found on the under surface at the keel and below a part of the mestome bundles including the larger and some of the smaller ones. The small mestome bundles are each enclosed by a parenchyma sheath showing four or five cells in cross-section. Stomata occur on both surfaces, but are far more abundant on the lower surface.

PANICUM DEPAUPERATUM. — Upper side of leaf deeply grooved between the bundles, with shallow grooves opposite on lower side; also shallow grooves opposite the mestome bundles on the lower surface. Keel is not prominent and its bundle is only slightly larger than the other largest mestome bundles. Bundles are enclosed in a sheath of stereome which is not fully developed in some of the smaller ones, the cells having lamellated and pitted walls. Outside of the stereome sheath is a parenchyma sheath found in connection with all the bundles. The parenchyma-sheath cells are of good size and show no green coloring matter. Two or more cells of the stereome sheath are replaced on the upper side by parenchyma-cells, a tier of which extends from the bundle upward to the subepidermal stereome strand of the ridge of the upper surface. Similar tissue connects the bundle with the subepidermal stereome tissue of the lower surface. A layer of rather thick-walled cells (probably tracheids) separates the hadrome from the leptome in the larger mestome bundles, but in the smaller ones the elements are not clearly differentiated. Subepidermal strands of stereome occur in the leaf-margins and above and below each bundle. The epidermal layer of the upper surface consists of colorless cells, very small over the stereome strands, with large cells in the grooves that probably function as bulliform cells. Inferior epidermal cells are colorless, of medium size between the mestome bundles, but very small over the stereome tissue opposite the bundles. Certain epidermal cells of the ridges of the upper surface are extended into stout, blunt-pointed hairs, and sharp-pointed unicellular hairs are borne in the grooves of both surfaces. Stomata occur on both surfaces on the sides of the grooves between mestome bundles. Assimilating cells fill the entire space between the epidermal layers and between the bundles.

CENCHRUS TRIBULOIDES.— Over the keel are two or three layers of bulliform cells forming one half the thickness of the leaf. A single layer extends over the upper surface of the leaf, being partially interrupted over the stereome strands. This layer forms nearly one third of the thickness of the leaf. The lower surface has an epidermal layer of smaller colorless cells which undoubtedly serve a similar purpose. The bundles are all enclosed in parenchyma sheaths. Large green cells surround the small mestome bundles, but these cells are considerably smaller in the sheaths of the larger bundles. The small bundles do not have the leptome and hadrome clearly differentiated. Subepidermal strands of stereome occur on the keel and margins of the leaf, and above and below the larger mestome bundles. To some extent the leaf is furrowed on the upper surface, typical bulliform cells occurring in the furrows, and short spines or hairs which are modifications of the epidermal cells appear on the ridges. Stomata are found on the sides of these furrows, but are much more abundant on the lower surface, where they occur in rows between the mestome bundles.

ANDROPOGON SCOPARIUS.— Over the midrib there are nine or ten rows of very large bulliform cells, of pyriform shape in cross-section (shown on *pl. 26, g*). These are a continuation of the epidermis of the upper surface of the leaf which is composed of a layer of water-cells, this layer making fully one third of the thickness of the blade. Outer walls of cells are much thicker than the partition walls between the cells. Over the mestome bundles the cells are smaller and some are extended into stout pointed hairs. Keel formed mostly of stereome-cells. Subepidermal strands of stereome tissue are found above and below the larger mestome bundles. The large bundles are provided with a sheath of stereome-cells, and a row of similar thick-walled cells separating the leptome and hadrome. Small bundles have a sheath of rather thin-walled parenchyma-cells, and are not clearly differentiated into leptome and hadrome. Stomata do not occur on the upper surface but are found in one or two rows of cells between the nerves of the lower surface. The guard-cells of the stomata are very narrow and have thick walls with the lumina nearly closed.

ANDROPOGON FURCATUS.— Superior surface covered by a layer of large colorless parenchyma or bulliform cells. Over the larger mestome bundles these cells are very small or the layer is interrupted entirely. Cells of the inferior surface are also colorless but much smaller than those of the upper surface. On both surfaces, especially over the mestome bundles, certain cells are extended into short, stout, unicellular hairs. Subepidermal strands of stereome occur opposite the larger mestome bundles on both the upper and lower surfaces ; small strands occur below nearly all of the smaller mestome bundles. The keel is chiefly composed of stereome-cells having very thick walls, in many cases almost obliterating the cell lumina. A small strand of stereome occurs on the upper side of the midrib and on each side of this strand are situated several rows of large bulliform cells. Each small mestome bundle is surrounded by a sheath of large parenchyma-cells from which radiates a row of green palisade-cells connected between the bundles with cells of similar tissue. Bundle of midrib nearly enclosed by sheath of parenchyma-cells, supplemented by cells of stereome on the leptome side. Leptome and hadrome separated by a row of thick-walled cells, which are probably tracheids. Elements are not clearly differentiated in the small mestome bundles. Stomata are abundant in the grooves of the inferior surface.

SPOROBOLUS VAGINAEFLORUS.— Rolls into a cylinder on drying. A group of five (one very large and four smaller) bulliform cells occur between the mestome bundles on the superior surface. A similar arrangement is found on the under surface, though the cells are smaller. Larger mestome bundles are each provided with a sheath of colorless parenchyma-cells and all bundles have sheaths of large, greenish-yellow parenchyma-cells with rather thick walls. Above and below each mestome bundle occurs a strand of stereome tissue, the one on the lower side being much broader than the one on the upper side. In some of the larger bundles having a stereome sheath the parenchyma sheath is interrupted next to the stereome strands, the interruption occurring more frequently on the leptome side. In some cases a single large colorless cell completes the connection. Epidermal cells are very small over stereome tissue and some of them are extended into spiny or hair-like projections which overhang the grooves, protecting both the stomata and the bulliform cells, and occurring on both superior and inferior surfaces. In the grooves of the inferior surface there are curious unicellular projections showing cell-contents and resembling glandular hairs. The spiny projections of the epidermal cells appear to be empty. Stomata occur along the sides of the bulliform cells on the upper surface and in the grooves of the lower surface. Mesophyl borders directly on the larger cells of the sheath and also upon the bulliform cells.

POA COMPRESSA. — Leaf is conduplicate on drying. Sections examined have large bundle in keel and seven mestome bundles on each side. Subepidermal strands of stereome occur in the keel, in the margins of the leaf, and opposite most of the mestome bundles on both the upper and lower surfaces, though not arranged regularly. In some cases these stereome strands connect the bundles with the epidermis. Epidermal cells of the upper surface have their inner walls in the same plane, but the outer extremities are very irregular. On each side of the keel the epidermal cells are greatly enlarged, and probably serve for storing water. Epidermal cells of the upper surface have the outer walls much thickened, which is not the case with the cells of the lower surface. The cells of the lower epidermis are quite uniform on their outer surface and have thin walls. The small mestome bundles are each provided with a parenchyma sheath; the larger bundles have a sheath of stereome inside the parenchyma sheath. Stomata are found on both surfaces; in slight depressions on the lower surface and in modified depressions of the upper surface, forming grooves * of nearly the depth of the thickness of the epidermal layer of cells. This layer is connected with the guard-cells of the stomata by very small cells which are doubtless modifications of the epidermal cells. Stomata of the lower surface are much larger than those of the upper surface. Stout blunt hairs or spines occur along the keel and the margins, and sharp-pointed ones are found on the upper surface opposite some of the mestome bundles.

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* O'Brien, MSS. (see fifth footnote on p. 585).

BROMUS TECTORUM. — Epidermal layers of the two surfaces are very similar, the cells being perhaps slightly larger below, of medium size and colorless. Some of them are extended into long, unbranched, unicellular hairs, which are slightly longer on the upper than on the lower surface. The small mestome bundles are not enclosed in sheaths as in *Cenchrus* and *Spartina*. The larger bundles have parenchyma sheaths, but the cells are small. Subepidermal strands of stereome are found in the leaf-margins and above and below the larger mestome bundles including the bundle of the keel. Mesophyl is rather compact and occupies the entire space between the epidermal layers not taken by the bundles. Stomata are found on both surfaces of the leaf.

SPARTINA CYNOSUROIDES. — Upper surface of the leaf much furrowed. Epidermis composed of small cells with rather thick walls curiously thickened or elongated on the outside, forming papillae or short hairs mostly with truncate or blunt points. At the bottom of each furrow are three rows of large colorless cells for storing water.* The stomata are situated on either side of this row of cells near the bottom of the furrow. Lower epidermis consists of small cells with very thick walls on the outside, nearly smooth. Subepidermal strands of stereome-cells occur above and below each mestome bundle, and each of the larger bundles is provided with a stereome sheath inside the sheath of green parenchyma which encloses all mestome bundles. The stereome sheath is entirely wanting in some of the small mestome bundles and is partially developed in others. There is no distinct keel, but the median mestome bundle is slightly larger than the others and has larger strands of stereome above and below it. The stereome sheath is also well developed, but the cells of the parenchyma sheath are rather small. A layer of thick-walled cells separates the leptome and hadrome.

CYPERUS FILICULMIS. — Leaf is conduplicate on drying. Very large colorless water-cells occur on superior surface : those in the center directly over the midrib are largest and all have rather thick outer walls with very thin partition walls between the cells. The sections studied had eleven mestome bundles, five on either side of the midrib. A subepidermal strand of stereome occurs

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*O'Brien, *l. c.*

on the under surface opposite nearly every mestome bundle, and on the upper surface each side of the bulliform cells. Bundle of the keel is partly surrounded by a sheath of stereome. Each mestome bundle has a sheath of large green parenchyma-cells. Epidermis of edges and under surface composed of small cells with rather thick outer walls. Stomata all on under surface, not depressed. Chlorenchyma-cells are arranged radially around the mestome bundles. On each side of the bundles and alternating with them is a row of cells or ducts containing a brown substance, probably tannin. A transverse section of the leaf is figured (*pl. 26, d*).*

STENOPHYLLUS CAPILLARIS. — Leaf has six rows of bulliform cells on the upper surface above the keel. There are only three bundles, one in center, and one on each side. There are five stereome strands, two on upper surface at edges of the layer of bulliform cells, and three on lower surface, one in keel and one on each side opposite those of the upper surface. Epidermis of lower and lateral surfaces is made up of small cells with rather thick walls. Each bundle has a sheath of stereome inside of which is a sheath of green parenchyma-cells. The central vascular bundle has the elements well developed but in the other mestome bundles the leptome and hadrome are not well differentiated. Stomata occur in the hollows of the lower surface each side of the keel and along the lateral surfaces between the stereome strands. Occasionally an upper or lateral epidermal cell is prolonged into a short, stout spine or hair. Certain cells or vessels are filled with a brown substance, probably tannin, similar to that found in *Cyperus filiculmis*. The assimilating cells radiate from the vascular bundles. A cross-section of the leaf is shown (*pl. 26, f*).

The stem is star-shaped in transverse section, having five points, a heavy strand of stereome occurring beneath the epidermis of each point, and opposite a vascular bundle. Two of the bundles are larger than the other three and have the elements well developed; the three smaller ones are not clearly divided into leptome and hadrome. Each bundle has a stereome sheath with sheath of green parenchyma inside like the leaf-bundles. Epidermis is made up of colorless cells with rather thick outer walls. These cells are small over the ridges but large in the grooves and probably function as bulliform cells. Stomata occur in the center of each groove. Central portion between the vascular bundles is composed of large pith-cells. Certain cells or vessels, as in the leaf, contain a reddish or brown substance. These are called tannin cells by Holm, who has figured the stem in transverse section and described in detail the structure of the whole plant of this as well as of other North American species included by him in the same genus (*Fimbristylis*).*

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* See also O'Brien, *l. c.*

CAREX PENNSYLVANICA. — Leaf is conduplicate on drying. Epidermis consists of small colorless cells larger on upper than on lower surface, and much enlarged over the keel, probably having the function of bulliform cells; outer walls are thick while the partition walls between the cells are thin. There are eleven mestome bundles, five on each side of the median one, which is slightly larger than the other mestome bundles, and is provided with a sheath of small parenchyma-cells replaced on the upper side by sclerenchyma-cells and on the lower by a large strand of stereome which forms the keel. The mestome bundles have sheaths of small parenchyma-cells and six of them are reinforced by strands of stereome both above and below. Between each pair of bundles (five on each side of keel) is a strand of large colorless thin-walled cells (parenchymatous tissue) which is probably for the storage of water.† Stomata occur on lower surface.

CAREX MUHLENBERGII. — Epidermal layer of upper surface is composed of rather large colorless cells, uniform in size except where partially interrupted over some of the stereome strands opposite the mestome bundles. The cells of the lower epidermis are much smaller. The bundles are small and the material studied had one bundle in the keel and nine on each side, making nineteen in all. Subepidermal strands of stereome occur on the keel, and above and below some but not all of the mestome bundles. Each bundle is enclosed in a green parenchyma sheath inside of which is a stereome sheath with cell lumina nearly closed. Between the mestome bundles are very large strands of water-

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*Holm, T. Am. Jour. Sci. IV. 7: 435–450, *f. 1–14.* 1899.

† Beal, W. J. The bulliform or hygroscopic cells of grasses and sedges compared. Bot. Gaz. 11: 321–326, *f. 10. pl. 10.* 1886.

holding tissue. The cell-walls are very delicate and broken down in some cases though intact in others. Holm in writing about the structure of *Carex Fraseri* * considers these strands as lacunes. Though the cell-walls may eventually break down completely, thus forming true lacunes, in the material which the writer has examined it seems that these strands must be considered as water-tissue. The water-strands are surrounded by assimilating cells. Stomata occur on the lower surface. *Pl. 26, b,* shows a transverse section of the leaf.

POLYGONELLA ARTICULATA. — Leaf nearly terete, slightly flattened. Large bundle in center surrounded by large parenchyma-cells, and about ten small mestome bundles in the outer portion of the parenchymatous tissue, which is evidently formed from the assimilating cells as the derivation was shown in the sections studied. Epidermal layer made up of large bulliform cells, certain cells being depressed and glandular (see *pl. 26, a*). Stomata are abundant around margin of cross-section. Between the epidermal layer and the central parenchyma-cells are three to four layers of assimilating palisade-cells containing chromatophores. The bundles contain spiral vessels. Central parenchymatous tissue has small intercellular spaces, and certain cells next to the palisade layer are filled with large crystals.

The stem is of similar structure, having an epidermal layer of cells for holding water, but a large number of the cells are glandular. Just inside the epidermal layer are two layers of green assimilating cells, inside of which is a more or less distinct layer of large circular cells. Next are ten bundles arranged radially in a circle. Inside the ring of bundles are large pith-cells. No stomata could be found on the stem. The leaf-sheaths or ocreae have large water-cells on the outside. Ten or eleven strands of stereome occur in the constricted places.

PLATANUS OCCIDENTALIS. — Upper epidermis of leaf is composed of rather small cells that appear rectangular in cross-section. These cells are not colorless and, as regards contents, resemble the palisade-cells. Palisade and mesophyl tissue very compact. Stomata occur on the under surface of the leaf, and both surfaces are covered especially when the leaf is young, with long branched multicellular hairs. These hairs have been figured by Solereder * and are very similar to the hairs of *Verbascum Thapsus*. The leaf contains no colorless water-cells.

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* Holm, T. Am. Jour Sci. IV. **3**: 121–128, *pl. 4*. 1897.

ARONIA ARBUTIFOLIA. — The upper epidermal layer consists of large water-holding cells with even outer walls and a thick cuticle. These cells are not uniform on their inner walls but some project much farther than others into the palisade tissue. The lower epidermis is made up of small, green cells. Each bundle is enveloped in a parenchyma sheath, and stereome tissue occurs below the bundles. Radiating crystals occur in a few of the cells of the mesophyl and palisade tissues. The stomata are very small and occur on the under surface, where they are protected by long curved unicellular hairs.

SAROTHRA GENTIANOIDES. — Stem has water-holding tissue surrounding the bundle and extending outward to the epidermis in four strands. The stem has large pith-cells in the center, surrounded by the xylem, which consists of vessels and lignified cells. Outside of the xylem there is a thin layer of phloem, beyond which there is a peculiar tissue of large irregular cells with rather thick walls curiously pitted. This is the water-tissue, extending in four strands from the central portion to the epidermis. Between these strands are found the palisade-cells. Opposite the palisade-cells occur the stomata which are small and not especially protected. The water-holding cells have thickened walls, probably for the purpose of strengthening the tissues.

The leaves are opposite and are reduced to mere scales or bracts. A uniform epidermal layer covers both surfaces, and the assimilating cells occupy the space between with the small bundles running through the green tissue. The stomata and epidermal cells are much like those of the stem. Large reservoirs are found in the green parenchymatous tissue of both leaf and stem. These are the pellucid dots common to the Hypericaceae, and are supposed to contain oil.

HELIANTHEMUM MAJUS. — Epidermis of the upper surface is composed of medium-sized colorless cells; lower surface has smaller cells, most of which contain green coloring matter. Stomata are abundant on the lower surface, which is densely covered

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*Solereder, H. Systematische Anatomie der Dicotyledonen, 877, *f. 184.* 1899.

with curious branched hairs. These hairs also occur on the upper surface, though not as abundantly. These hairs are nearly stellate, or radiating, but are not very closely appressed and must be of great value in preventing the loss of water. Between the branched hairs on both surfaces are small glandular hairs. The branched hairs (see *pl. 26, h*) are very similar to those of *Cistus Creticus* L. and the glandular hairs resemble those of *Cistus ladaniferus* L., both of which are figured by Solereder.* The palisade layer makes up half the thickness of the leaf and the mesophyl tissue is rather compact. Each bundle contains spiral vessels and has a sheath of parenchyma-cells.

VERBASCUM THAPSUS. — Both upper and under surfaces of the leaf are covered with peculiar branched multicellular hairs, which must be an important factor in preventing loss of moisture through transpiration. Glandular hairs which are also multicellular occur on both surfaces. The branched hairs are long, having a central axis the length of which is from twice to three times as great as the thickness of the leaf. The central axis is pointed at the apex and bears one, two or three whorls of pointed, horizontal, lateral branches.

LINARIA CANADENSIS. — Leaf narrow with revolute margins. The upper epidermis is composed of colorless cells which are extremely irregular in size and shape. Irregular papillae or wart-like projections on the surface of the leaf result from the irregularity of the cells. The lower epidermis is quite similar to the upper epidermis except under the midrib, where the cells are much larger and more regular in shape. The entire epidermal tissue is adapted for holding water. Stomata occur on both surfaces of the leaf, and are not depressed, but sometimes occur on the raised portion.

CHRYSOPSIS FALCATA. — Leaf conduplicate on drying. Epidermal cells of both surfaces nearly uniform in size and shape and with outer walls very strongly thickened. There are two palisade layers — one beneath the epidermis on each surface. Between the two palisade layers is a row of small mestome bundles surrounded by parenchymatous tissue, made up of large thin-walled mostly colorless cells. Some of these cells form sheaths for the bundles, and others occupy the space between the sheaths. Green coloring matter is found in a few of these cells, but apparently they have been developed for water-storage purposes. A large amount of this tissue surrounds the midrib. The bundle of the midrib is nearly surrounded by two strands of stereome — the larger occurring on the leptome side and the smaller on the hadrome side. Similar though smaller strands of stereome are found in connection with four of the larger mestome bundles, two of these having stereome on the leptome side only, while the other two have it on both sides of the bundle. Small glandular hairs project from the cuticle on both surfaces. External surface of the cuticle is roughened by small projections. Stomata occur on both surfaces and are slightly raised rather than depressed.

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* Solereder, H. Systematische Anatomie der Dicotyledonen, 92, *f. 21*. 1898.

IONACTIS LINARIIFOLIUS. — Leaf is thick and rough. The entire epidermal layer of both surfaces is composed of colorless water-holding cells of uniform size much thickened on the outer walls. The thickened cuticle bears short, stout, pointed projections having openings into the cells. The two epidermal layers form about one third of the thickness of the leaf. A strand of stereome occurs on the leptome side of the bundle of the midrib. This is the only bundle in which the elements are clearly differentiated, though there are eight small mestome bundles in the leaf, four on each side of the midrib. On the keel there are three layers of nearly colorless, thick-walled parenchyma-cells. The palisade layer and mesophyl are very compact. Stomata occur on both surfaces, and have a peculiar structure with the cuticle projecting over the depressed guard-cells. The projection is slightly raised, and appears as a round hole in the leaf when examined from the surface (see *pl. 26, c*).

ANATOMY OF SUBTERRANEAN PARTS

In the following description of roots the measurements are given only for the specimens examined. It should not be inferred that the roots are uniform in size or that they have the same number of vessels. These measurements are given to show as clearly as possible the relation between the size of the root, its central cylinder and its largest vessels.

PANICUM DEPAUPERATUM.— The material examined has eight large vessels in the root with nineteen phloem patches arranged radially outside of the vessels. Between and around the vessels and phloem patches, and in the center of the root, the tissue is made up of rather thick-walled parenchyma-cells with small intercellular spaces. Endodermis is composed of rather thin-walled cells of medium size. Cortex is made up of thin-walled cells mostly tearing off in cutting.

Diameter of central cylinder,	.29 mm.
" " largest vessels,	40 μ

PANICUM UNCIPHYLLUM.* — The sections examined show several large vessels in the root between and around which are rather thick-walled parenchyma-cells. Phloem patches are small and numerous, arranged in a circle around the vessels, which is the usual arrangement in grasses. The endodermis is well developed and is composed of large cells rectangular in transverse section; cell-walls are of medium thickness, and there are a few small intercellular spaces between the endodermis and the central tissue. There is no well-developed pericycle. The cortex is made up of large cells with very thin undulating walls. In one or two layers next to the endodermis the cells are rectangular in cross-section, but the other cortical cells are very irregular. Some of the cells in the central cylinder are filled with starch-granules.

Diameter of root,	.35 mm.
" " central cylinder,	.20 mm.
" " largest vessels,	27 μ

ANDROPOGON SCOPARIUS.— In the specimens examined there are thirteen vessels arranged in a circle half-way from the center to the periphery of the root and separated by rather thick-walled parenchyma-cells. Just outside the row of vessels are very small patches of phloem, hard to make out except by the thin cell-walls. Between these areas and the endodermis the cells are mostly empty, with rather thick pitted walls. A few cells contain starch-granules and some appear to be sieve-tubes. Endodermis prominent; cells rectangular in cross-section, walls thin on the outside but thickened peculiarly on the inside and showing lamellae and pits. Cortex consists of three or four layers of thin-walled cells rectangular in transverse section, mostly tearing off in cutting.

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* See Rhodora, 3: 121. 1901.

Central portion of root is composed of mostly empty cells which appear circular in cross-section and have fairly thick walls with intercellular spaces at the angles. Structure is practically the same as is shown in the figure of *A. furcatus* (*pl.* 27, *d*).

ANDROPOGON FURCATUS.— The central portion of the root is made up of rather thick-walled pitted starch-cells, which are nearly circular in transverse section, *i. e.*, their lumina are circular and nearly uniform in size. The vessels are arranged in a circle having a diameter two thirds as great as that of the root-section. The roots examined contained eighteen vessels, the largest ones having a diameter of only 34 μ. Diameter of root is 1 millimeter. Just outside of the circle of vessels and sometimes alternating with them are the small patches of phloem elements. The endodermis has peculiar cells with the inner walls much thickened and pitted. Between the endodermis and the phloem region are starch-cells resembling those of the central portion except that the walls are thicker and more strongly pitted. This tissue corresponds to the sheath or pericycle but is not of the structure usually found in bundles. The larger vessels are the only portion of the xylem elements that can be made out in cross-section. The cortex is composed of four or five layers of thin-walled cells resembling cork, which are mostly empty and appear oblong in a cross-section of the root.

The rootstock is thickened at the nodes (see *pl.* 27, *c*), and these nodes are composed chiefly of rather thick-walled parenchyma-cells crammed with starch granules. These cells are nearly circular in cross-section and larger than the corresponding cells of the root. The vascular bundles penetrate this tissue at nearly equal distances and seem to extend in all directions, for bundles cut transversely, longitudinally and obliquely occur in the same section. These have been deflected at the thickened nodes and are parallel between the nodes. The starch-cells are usually larger than the vessels of the bundles. The latter are made up of long pitted cells. The cortex is thin and is made up of parenchyma with cells much smaller than those of the central portion and packed less closely with starch-granules. The endodermis surrounds the entire central portion of starch parenchyma-cells and bundles and its cell-walls are thickened on the inner side.

SPOROBOLUS VAGINAEFLORUS. — Small root has two large vessels and several much smaller ones. Endodermis prominent, of cells with inner walls strongly thickened showing lamellae and pits. Pericycle of thick-walled cells. Cortex made up of one or two layers of rather irregular large cells with walls of medium thickness and brown color.

Small root.	Diameter of central cylinder,	.1 mm.
	" " largest vessel,	20 μ

In larger roots there are four large vessels and two or three small ones. Some roots have three large vessels. Endodermis has cells with inner walls much less thickened than in small root, though lamellae and pits are still prominent. Cortex composed of about five layers of cells, the outer layers having thicker walls than the inner layers. No starch. Cross-sections of both large and small roots are figured on *pl. 27*, *b* and *c*.

Large root.	Diameter of entire root,	.25 mm.
	" " central cylinder,	.18 mm.
	" " largest vessels,	37 μ

POA COMPRESSA. — Young root has a single vessel in the center with rather thick-walled cells between this and the endodermis. The endodermis is composed of thick-walled lamellated cells. Outside and next to the endodermis is a layer of cells quite different from the endodermal cells and those of the cortex. These cells are oblong in transverse section, have thicker walls than the cortical cells, and of the same color as the endodermal cells. Cells of the cortex have thin walls, and are irregular in shape.

Diameter of root,	.25 mm.
" " central cylinder,	.1 mm.
" " " vessel,	17 μ

Rhizome: central portion is made up of large empty pith-cells with large intercellular spaces. This tissue is surrounded by a layer of sclerenchymatous tissue several cells in thickness with which all of the bundles are connected; some of the bundles are entirely surrounded by it, but most of them and especially the larger bundles are just inside this ring of sclerenchyma. Outside are small empty parenchyma-cells with thin walls and small intercellular spaces, the epidermal layer having thicker walls. The sclerenchyma-cells show lamellae and pits.

SPARTINA CYNOSUROIDES. — Central portion of root is provided with vessels arranged in the form of a circle as seen in cross-section, with the phloem tissue immediately surrounding the circle of vessels. Endodermis apparent, formed of small, rather thin-walled cells joined on the outside by three or four rows of thick-walled circular cells with large intercellular spaces. From this tissue narrow strands of cells extend to the cortex, forming immense lacunes. Small simple root-hairs extend from the outer cells of the cortical layer. The central portion inside the circle of vessels is made up of rather thin-walled cells appearing circular in cross-section, with intercellular spaces at the angles. There is no starch. The structure of the root is shown on *pl. 27, f.*

Diameter of root,	1.5 mm.
" " central cylinder,	0.6 mm.
" " largest vessels,	37 μ

CYPERUS FILICULMIS. — The material examined shows a single large vessel in the center of the root surrounded by rather small cells apparently empty. Endodermis composed of very thick-walled cells next to cortex. These are light-brown in color and show both lamellae and pits. Cortex dark-brown in color and made up of large rectangular cells with rather thick walls (see *pl. 27, a*).

Diameter of root,	.15 mm.
" " central cylinder,	.11 mm.
" " vessel,	33 μ

Corm : transverse sections show it to be made up of rather thin-walled parenchyma-cells densely packed with starch. These cells are circular, hexagonal or pentagonal in shape with pitted walls. Small intercellular spaces occur at the point of union of three cells. Spiral vessels occur in the bundles, which are small and irregularly distributed throughout the central portion of the rhizome. Certain cells are filled with peculiar brown substance presumably the same as is found in the leaves. This does not dissolve upon long standing in xylol.

STENOPHYLLUS CAPILLARIS.— The material examined shows a single large vessel in the center of root, surrounded by thick-walled cell tissue containing the phloem patches. Endodermis formed of large thick-walled cells, reddish brown in color and strongly pitted and lamellated. Cortex composed of large irregular thin-walled cells. All cells of the root are colorless.

Diameter of root,	.25 mm.
“ “ central cylinder,	.11 mm.
“ “ central vessel,	33 μ

Carex Pennsylvanica.—A section of the root shows six large vessels in central portion and just outside of the region occupied by the vessels occur the phloem patches. Endodermis composed of deep narrow cells with inner walls very much thickened, with pits and lamellae. Cells of endodermis and of central portion contain starch. Outside of endodermis are several layers of thick-walled, apparently empty, brown sclerenchyma-cells, only those of the first layer having a regular form. Some of these layers are separated or pulled off in places, forming large lacunes. Outside of this tissue are three layers of thin-walled parenchyma-cells. In some cases the tissue around the lacunes has separated, and the entire gap has been filled in by parenchymatous tissue.

Diameter of root,	.65 mm.
“ “ central portion,	.35 mm.
“ “ largest vessels,	33 μ

Rhizome: central portion is composed of circular cells with rather thin pitted walls and devoid of large vessels. The bundles are arranged in a circle and the vessels are no larger than the cells in the central portion. Endodermis apparent but not distinct as in the root: cells resemble others except that they have thicker walls and have a more regular arrangement. Cortex is made up of parenchyma-cells and separates from the central cylinder. There are three distinct vascular bundles in the cortex, probably belonging to leaf-scales or to branches. Some of the cells of the central portion contain starch.

Diameter of rhizome,	.95 mm.
“ “ central portion,	.71 mm.
“ “ vessels,	20 μ

Salomonia biflora (*Polygonatum biflorum*).—Root: bundle contains from six to eight good-sized vessels with xylem arranged radially, the transverse section showing six points. Endodermis distinct, of rather thick-walled cells except those cells opposite the xylem rays which have thin walls, probably for the purpose of transferring water between the bundle and the parenchymatous tissue. Central cylinder is surrounded by a large mass of parenchyma-cells having thin walls and containing no starch.

Diameter of root,	.78 mm.
" " central cylinder,	.18 mm.
" " largest vessels,	40 μ

Rhizome: consists of large thin-walled parenchyma-cells in which tissue the concentric bundles are rather irregularly arranged. Vessels of the bundles are much smaller than the parenchyma-cells surrounding the bundles. A few cells contain large bundles of raphides or acicular crystals. Cells of outer portion somewhat smaller than those in central part and contain smaller crystals. Endodermis not apparent. The structure of a small root is shown on *pl. 28, a.*

VAGNERA RACEMOSA. — Root: bundle arranged radially with nine points, nine phloem patches and six large vessels. Endodermis distinct, of cells rectangular in cross-section, and with thicker walls than the cells of the surrounding tissue. Opposite the xylem points, the thick-walled endodermal cells are replaced by thin-walled cells, thus making a connection between the xylem and the cortex. The cortex is composed of very large thin-walled parenchyma-cells with intercellular spaces.

Diameter of root,	1.25 mm.
" " central cylinder,	.39 mm.
" " largest vessels,	66 μ

Rhizome: central tissue is made up of large thin-walled cells with many intercellular spaces. The bundles extend through this tissue at quite regular distances apart and are of the type found in Liliaceae and other monocotyledons with phloem enclosed in a xylem sheath of thick-walled pitted vessels. Endodermis composed of small cells. Certain large cells in the central portion contain bundles of raphides. Cortex is composed of large circular parenchyma-cells. Whole structure of roots and rhizome much like that of *Salomonia biflora*, to which it is closely allied.

CYPRIPEDIUM ACAULE. — Root has radially arranged bundle with eight xylem points, and no very large vessels. Endodermis present, of thick-walled cells which are interrupted opposite the radiating points of xylem, and replaced by thin-walled cells. The cortex is made up of very large, circular, parenchyma-cells with thin walls, and intercellular spaces. Some of the cells contain small quantities of starch. The two outside layers contain smaller cells which are rectangular in cross-section.

Diameter of root, about	2.00 mm.
" " central cylinder,	.45 mm.
" " cells of cortex,	.13 mm.
" " largest vessels,	30 μ

POLYGONUM CONVOLVULUS. — Primary structure not found in the material examined, but the secondarily thickened root is remarkable for the size of the vessels, some of which are from one sixth to one seventh the diameter of the root. There are no large parenchyma-cells in the cortex, but several strands of thick-walled cells run through the cortex near the periphery. The transverse section of a secondarily thickened root is shown on *pl. 28, c.* Roots examined were somewhat flattened.

Diameter of root,	.83 x 1.0 mm.
" " largest vessels,	106 x 166 μ

FRAGARIA VIRGINIANA. — Central cylinder is rather small and xylem elements appear triangular in cross-section, and surrounded by the phloem. Endodermis is distinct, being made up of small cells, with walls of medium thickness, filled with starch-granules. Central cylinder is surrounded by much parenchymatous tissue of large thin-walled cells mostly circular in cross-section. Cortex separates in cutting, and is made up of circular cells a trifle smaller than the parenchyma-cells and with thicker walls. Certain cells of the cortex, parenchyma and central portion contain brown granules; such cells are also found between the xylem vessels, and several cells near the endodermis contain a brown or yellow substance resembling resin. Abundance of parenchymatous tissue must be of considerable use in storing water.

Diameter of root,	1.00 mm.
" " central cylinder,	.25 mm.
" " largest vessels,	27 μ

Potentilla Canadensis. — Primary structure shows three vessels in the bundle surrounded by thin-walled cells — the phloem. Endodermis is composed of large cells nearly circular in cross-section, with dark walls of medium thickness. Pericycle of smaller cells with light-colored walls. The bundle begins as a diarch. The cortical cells are very large and irregular in shape with thin undulating walls. Older root shows three-pointed xylem with alternating phloem patches. No endodermis immediately surrounds the bundle, but near the periphery of the section is a layer of small rectangular cells greatly resembling an endodermis. These cells are closely packed with starch. Between this layer and the xylem of the bundle the tissue consists of rather thick-walled parenchyma-cells, most of which appear empty, but a few are densely packed with granules.

Diameter of root,	.18 mm.
" " central cylinder,	.1 mm.
" " largest vessels,	13 μ.

Crotalaria sagittalis. — Primary structure not observed. Roots in which secondary thickening has taken place have from twenty-five to thirty large vessels arranged irregularly. Strands of thick-walled sclerenchyma-cells run through the cortex near the periphery and some similar cells occur in the central cylinder. Resembles *Cassia* very closely in structure, but the sclerenchymatous tissue is more abundant than in *Cassia.* Shown on *pl. 28, d.*

Diameter of root (thickened),	.1 mm.
" " central cylinder,	.5 mm.
" " largest vessels,	46 μ.

Lupinus perennis. — Central cylinder of the root is oval in cross-section, and small for the size of the root. Xylem has the diarch arrangement whith phloem on both sides. Sclerenchyma strands appear in connection with the phloem tissue. Endodermis is apparent, though the cells are rather irregular and have thin walls. Outside the endodermis the root is made up of very large thin-walled parenchyma-cells, the largest cells having a diameter of 50 μ. Cortex consists of a single layer of small thin-walled cells with small brown granules.

Diameter of root,	.5 mm.
" " central cylinder (oval),	.2 x .3 mm.
" " largest vessels,	20 μ.

MEIBOMIA sp.—The primary root shows three large vessels and three smaller ones in the bundle which seem to be entirely surrounded by phloem. The phloem contains several strands of sclerenchyma-cells with closed lumina. The endodermis is composed of oblong thin-walled cells. The pericycle consists of similar but smaller cells. The cortex has very large cells with thin undulating walls and some intercellular spaces. Considerable lignified tissue is formed in the secondarily thickened roots and the vessels are large.

Diameter of root,	.31 mm.
" " central cylinder,	.18 mm.
" " largest vessels,	30 μ.

CASSIA CHAMAECRISTA.—Most of the preserved material shows secondary thickening in the roots, but the root from a young seedling exhibits the primary structure. In the latter there are four large vessels, one in the center and the others around it forming a three-pointed xylem in transverse section. This is surrounded by the phloem. Endodermis is prominent, of good-sized cells, oblong to circular in cross-section, and with walls only slightly thickened. Just inside the endodermis and near the three radiating xylem points are three strands of sclerenchyma-cells. The lumina are nearly closed and the lamellae can be distinguished. The cortex is composed of large parenchyma-cells with thin undulating walls.

Diameter of entire seedling root,	.3 mm.
" " central cylinder,	.16 mm.
" " largest vessels,	66 μ.

In roots which have undergone secondary thickening, the vessels are large and numerous, varying from thirty-six to fifty in the sections examined and probably even more in larger roots. These vessels are pitted, approaching scalariform. About half of the small xylem-cells in the center between the vessels stain dark after standing for a long time in chloriodide of zinc, though these were not stained at first by this reagent. They are probably parenchyma xylem-cells with cellulose walls which stain only after standing for a long time. There are curious strands of lamellated sclerenchyma-cells with narrow lumina running through the cortex near the periphery. None of the cells contain starch.

Diameter of entire root,	.9 mm.
" " largest vessel,	66 μ.

VIOLA SAGITTATA. — The xylem is surrounded by phloem, though very young roots show the diarch arrangement. Endodermis present, composed of small rather irregular thin-walled cells. Cortex is made up of larger cells which have thicker walls. A few of the cortical cells are filled with a dark-brown substance.

Diameter of root,	.6 mm.
" " central cylinder,	.25 mm.
" " largest vessels,	23 μ.

ONAGRA BIENNIS. — Real primary structure not found, but sections of small roots show a number of large vessels in central portion surrounded by woody tissue. Around this is the phloem containing many large cells or vessels with raphides. On the outside of the phloem tissue are two distinct layers of phellogen, the cells being large, nearly uniform in size, and rectangular in cross-section. These cork-cells have thin dark-colored walls and have developed from the pericycle, according to Strasburger (Lehrbuch der Botanik, ed. 5, 119), and have crowded and flattened the endodermal cells beyond recognition. These flattened endodermal cells may be found on the outside of the cork layer. In one section the cork-cells have not yet fully developed and the endodermal cells still remain. Several layers of cork-cells occur in older roots. Outside of the cork layer are several layers of much flattened cells which peel off in handling and are probably the bark. The cells have brown walls.

LYSIMACHIA QUADRIFOLIA. — Several small vessels but no very large ones are found in the center of the root. The phloem patches are five in number and close to the endodermis. Endodermis is composed of cells that appear oval or oblong in cross-section; the walls are quite thick and are lamellated and pitted. The pericycle is made up of similar though slightly smaller cells. In the center of the root there is a group of sclerenchyma-cells with very thick walls which are lamellated and pitted. The cortical cells are rather large, with thin undulating walls and very small intercellular spaces. The outer layer has cells of much more regular shape than the others, and some are prolonged into unicellular root-hairs. Throughout the whole root but especially numerous in the center are certain cells filled with a dark-brown substance, resembling tannin, but which is probably a resin, as Bary refers to resinous substances in the roots of other members of the genus.* Roots which have undergone secondary thickening show a large group of thick-walled, probably lignified cells in the center, outside of which is a zone containing the xylem and phloem patches. Running through this zone are radial strands of lignified cells and one or two rows next to the cortex. The cortex is made up of cells which are oval or oblong in cross-section with intercellular spaces. With the exception of the outer layer which has colorless cells, the cell-walls are brown in color though none of the cells as in the primary root are filled with tannin.

Diameter of root,	.65 mm.
" " central cylinder,	.25 mm.
" " largest vessels,	23 μ.

Rhizome: The central portion is made up of pith-cells nearly circular in cross-section. Some of these are colorless but many are filled with small brown granules, while others are entirely filled with the brown substance. A thin layer of small-celled sclerenchymatous tissue surrounds the pith. The cortex is formed of large circular cells, much resembling the pith-cells, and many contain resin. Large intercellular spaces occur in the cortex. Half way from the sclerenchymatous layer to the periphery is a row of ducts or intercellular passages containing resin. The outside of the rhizome is covered with what appear to be simple hairs.

ASCLEPIAS VERTICILLATA. — The bundle of the root contains no large vessels, but there are many small ones. Endodermis can be made out in specimens studied, though it is evident that secondary thickening of the root has commenced. The cells are oblong in transverse section and have thin walls. The xylem has four points in young root. The cortex is made up of large cells circular in cross-section and with many intercellular spaces towards the periphery; near the central cylinder the cells are oblong and the tissue much denser. Most of the cells are closely packed with starch.

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* Bary, A. de. Vergleichende Anatomie der Vegetationsorgane der Phanerogamen und Farne, 219. 1877.

Diameter of root,	1.2 mm.
" " central cylinder,	.32 mm.
" " largest vessels,	27 μ.

Trichostema dichotomum. — Very small root shows that the bundle began as a diarch, with endodermis composed of thin-walled cells rectangular in transverse section. The cortex cells are thin-walled, colorless and very large. Roots that have undergone secondary thickening have many large vessels with pitted walls. In the sections studied there were from forty-five to fifty of these vessels that were distinctly larger than the other xylem cells. Structure of root shown on *pl. 28, b.*

Diameter of root,	.9 mm.
" " central cylinder,	.65 mm.
" " largest vessels,	60 μ.

Verbascum Thapsus. — Small root has a number of small vessels in the center surrounded by phloem. Endodermis prominent, cells oblong in transverse section. Cortex is made up of very large thin-walled cells. Older root has a large central cylinder, containing many pitted vessels of rather small size. The endodermis can still be made out in some sections. The cortex now consists of several layers of small cells which are oblong in cross-section, and nearly free from starch.

Diameter of root,	.13 mm.
" " central cylinder,	.5 mm.
" " largest vessel,	5 μ.

Linaria Linaria. — Small root shows phloem surrounding the xylem. Endodermis present. Cortical cells are very large and mostly colorless, but a few are filled with brown granules. Secondarily thickened roots have several large vessels with measurements as follows:

Diameter of root,	.72 mm.
" " central cylinder,	.5 mm.
" " largest vessels,	36 μ.

LINARIA CANADENSIS. — Primary root shows three vessels in center surrounded by phloem. Endodermis distinct, of small cells that appear oblong in cross-section. Outside of the endodermis are three rows of very large cortical cells, circular, pentagonal or oblong in transverse section. In secondarily thickened root the vessels are not large, and are pitted. The cortex is a thin layer of large thin-walled cells.

Diameter of root,	.09 mm.
“ “ central cylinder,	.02 mm.
“ “ largest vessels,	4 μ.

CHRYSOPSIS FALCATA. — A cross-section of the xylem of the primary root shows a four-pointed radial arrangement, with two large vessels and two small ones in the center. Endodermis apparent, cells nearly circular in transverse section, with thin walls. Pericycle of similar structure. The cortical tissue is formed of about eleven layers of large colorless parenchyma-cells, circular in cross-section, with thin walls, and intercellular spaces. Walls of the two outer layers are brown in color.

Diameter of root,	.45 mm.
“ “ central cylinder,	.13 mm.
“ “ largest vessels,	17 μ

SOLIDAGO NEMORALIS.— Bundle has diarch arrangement in young root, and the vessels are very small. Endodermis is apparent, and the cortex is made up of large cylindrical cells with contents plainly visible. In roots that have undergone some secondary thickening there are several good-sized vessels and the cortical cells are large and colorless with large intercellular spaces, while the endodermis can still be made out. The structure closely resembles that of *Chrysanthemum Leucanthemum.*

Diameter of root,	.55 mm.
“ “ central cylinder,	.26 mm.
“ “ largest vessels,	43 μ

IONACTIS LINARIIFOLIUS. — Primary structure of root has a bundle with three-pointed xylem in cross-section and containing three large vessels. Endodermis is prominent and is composed of thin-walled cells which vary from rectangular to circular in cross-section. The cortical tissue is made up of large, circular, colorless cells with rather thick walls and large intercellular spaces.

Diameter of root,	.46 mm.
" " central cylinder,	.15 mm.
" " largest vessels,	20 μ

LEPTILON CANADENSE. — Central cylinder contains three vessels in primary root. The endodermis is prominent, being made up of thin-walled cells that are rectangular in cross-section. The pericycle is formed of similar but smaller cells. The cortical tissue is very similar to the structure found in other composite roots, and consists of large thin-walled circular cells with large intercellular spaces. The outside layer has thicker walls.

Diameter of root,	.2 mm.
" " central cylinder,	.1 mm.
" " largest vessels,	13 μ

ANTENNARIA NEGLECTA. — Transverse section of the xylem is a radial five-pointed star with phloem patches between the points. There are no large vessels. The endodermis is apparent, with cells nearly circular in cross-section and walls only slightly thickened. The pericycle is composed of similar but smaller cells The cortical tissue is made up of from fourteen to fifteen layers of rather large colorless cells oblong in transverse section.

Diameter of root,	.85 mm.
" " central cylinder,	.25 mm.
" " largest vessels,	17 μ

CHRYSANTHEMUM LEUCANTHEMUM.— Bundle has radial arrangement, with four xylem points and four phloem patches. The vessels are not large. Endodermis composed of thin-walled cells. The cortex is formed of very large colorless thin-walled parenchyma-cells with large intercellular spaces. The peripheral layer is of a brown color.

Diameter of root,	.56 mm.
" " central portion,	.23 mm.
" " largest vessels,	17 μ
" " cortical cells,	33 μ

ARTEMISIA CAUDATA. — One very large vessel in the center is surrounded by several smaller vessels and lignified cells showing lamellae. The phloem surrounds this tissue. Endodermis is still present, though secondary thickening has evidently begun, in the roots examined. Cells of the cortex are hexagonal and pentagonal in shape, are very large and have thin walls. The structure of the root is quite similar to the root-structure of the other members of the Compositae that have been examined in preparing this paper.

Diameter of root,	.51 mm.
" " central cylinder,	.28 mm.
" " largest vessel,	33 μ

THE STRUCTURE CONSIDERED IN RELATION TO THE ENVIRONMENT

It is commonly known that the different kinds of plants differ in their minute structure as well as in their external gross appearance, though in most cases to a less marked degree. Nearly all of the works on structural botany contain figures illustrating the various plant tissues and forms of cells. The functions of most of these specialized tissues have been known for many years, but the variations were regarded as properly belonging to different species of plants instead of as special adaptations for the benefit of the plant that might finally lead to the erection of species. It has been during the last few years only that we have looked upon plants as being capable of great modification by environment, even as regards external characteristics. Much more recently has it been shown that histological differences, which fundamentally precede gross external differences, are the result of environment. Under favorable conditions perhaps we do not notice the changes so much, but when the conditions become unfavorable it will always be found that certain plants have been able to live where others have perished, and all because of slight variation in some direction which proves beneficial. So natural selection acting through many generations has preserved these beneficial variations, which through the laws of heredity and by the aid of continued natural selection have reached a higher and higher development.

Thus we have in aquatic plants specially developed air-passages and bladder-like floating tissues. Hydrophytes of fresh water also differ from those of salt water (halophytes) in their cell structure.

Desert plants (xerophytes) have many peculiar adaptations for the conservation of water. Large parenchyma-cells, or increased palisade tissue, become abundant, in many cases forming a fleshy or succulent plant which reaches the highest development in the Cactaceae.

But many plants have developed special cells for water-holding purposes, while others through their root system have provided a ready means of taking up water and some have a combination of both arrangements. This is known as a xerophytic structure and is found in desert plants, though it is not uncommon to find a similar structure in beach plants or even hydrophytes. *Salicornia* and certain species of *Atriplex* which have succulent stems or leaves will serve to illustrate this point. It has been explained that, as these plants commonly grow on salt marshes and are often covered by the tide, on account of the saltness of the water the plants may not be able to make use of it and really depend upon showers and the dew for their water supply ; hence the necessity of conserving this until more water may be obtained.

It is also claimed that swamp plants develop similar structures on account of the accumulating quantity of acid derived from the humus of the soil through chemical changes in it ; that even swamp plants on account of this acid may not be able to obtain plenty of pure water and these structures are developed for the purpose of economy in using it.

Be this as it may, the fact remains that we do find the same or similar structures in plants of quite different habitats. Cowles found that willows, which are perhaps the most typical of swamp trees, were best able to adapt themselves to the conditions of the advancing sand dunes of Lake Michigan * because when partially buried by the sand to the depth of many feet the tree put out new roots and was not injured. Many other trees like oaks and pines were killed. Schimper goes still farther in showing the similarity between xerophytes and bog plants, and also states that there are no structural differences by which we can distinguish xerophytes from halophytes. Where differences exist they are chiefly physiological in character and relate to the effect of light, heat and a moist or dry air upon the plant. " Physiological dampness then is correlated with a hydrophytic, and physiological dryness with a xerophytic vegetation." *

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* Cowles, H. C. Bot. Gaz. **27** : 292. 1899.

With this brief general survey of the subject we will now discuss the ecological structure of some of the plants of the North Haven sand plains.

A number of perennial plants, of which the milkweeds (*Asclepias*), *Lespedeza*, *Baptisia tinctoria*, *Lupinus perennis*, *Cracca Virginiana* and *Meibomia* are good examples, have long roots that go down deep into the subsoil and bring up moisture from a lower level to supply the needs of the plants. Clovers also do this and are often able to withstand drought and even make growth when other plants fail and perish. *Asclepias Syriaca* and *A. amplexicaulis* grow quite luxuriantly upon the sand and in no small measure must this be attributed to the deep growing roots and rhizomes, which are not only able to obtain water but may hold it for some time or until it can be used by the plant. (*Pl. 24, b*, shows a colony of *Asclepias Syriaca.*) *A. verticillata* is not a deep-rooted plant, but the roots are fleshy and the leaves have a narrow form exposing much less surface than the broad-leaved species. The milky juice of these plants, while not thoroughly understood, seems to be correlated with other xerophytic characters and probably prevents the escape of water. If the plant is cut or wounded the milky juice soon closes over the wound, forming an impervious rubber-like coating. On account of this substance many plants with a milky sap, like *Lactuca*, *Asclepias* and *Euphorbia*, will wilt when cut and placed in water, because the water cannot enter the stem through the coating formed by the milky juice.

Some of the legumes in addition to their habit of deep-rooting, have the surface of stem and leaves well protected by hairs. *Lespedeza Stuvei* and *Cracca Virginiana* are good examples.

A fleshy leaf has been considered the most perfect type of xerophytic adaptation, and this is found in *Polygonella articulata* and to some extent in *Euphorbia polygonifolia*.

In *Cypripedium acaule* and certain liliaceous plants like *Salomonia* (*Polygonatum*) and *Vagnera* (*Smilacina*) there is some degree of fleshy development of the leaf and stem tissues. We find also that these last named plants have thick fleshy roots and rhizomes that can, doubtless, store water as well as food. These plants also have thin-walled cells in the endodermis of the small roots opposite the xylem rays, in order to permit the rapid transfer of water between the xylem and cortex.

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* Schimper, A. W., *l. c.* 4.

Linaria Canadensis, which is abundant at North Haven around the barren tract, making the field fairly blue in June, has leaves that are linear in shape and somewhat succulent. Another class of plants, to which belong several members of the Compositae, and of which *Ambrosia artemisiaefolia*, *Artemisia caudata* and *Achillea Millefolium* may be mentioned, possess finely divided leaves which are more or less hairy as a means of reducing the loss of water.

Ionactis linariifolius and *Chrysopsis falcata* have narrow rigid leaves exposing a minimum amount of surface and seem well fitted for dry situations. A microscopical examination of the leaves exhibits special adaptations for conserving the moisture which they contain. Both have a much thickened cuticle and in the former the stomata are well protected, while the leaf of the latter has a palisade layer beneath the epidermis of each surface.

Sarothra gentianoides (*Hypericum nudicaule*) has the leaves reduced to mere scaly bracts and the stem contains special water-holding cells with thick walls peculiarly pitted and green assimilating cells that enable it to perform the function of leaves. The root system contains large vessels and is well developed for the rapid supplying of water.

The frost flower, *Helianthemum majus*, a common plant of the sand plains, has stem and leaves well protected from excessive loss of water by a dense covering of appressed radiating hairs (see *pl. 26, h*). The mullein, *Verbascum Thapsus*, has both surfaces of the leaf covered by long branching multicellular hairs, which must be a great protection from the loss of water. Similar hairs are found on the leaves of *Plantanus occidentalis*, and are figured by Solereder. * *Antennaria neglecta* and *Gnaphalium obtusifolium* (*G. polycephalum*) have a woolly covering of white hairs on the under side of the leaves where the stomata are situated.

It is in the histology of the grasses and sedges, however, that we find the most interesting and most striking examples of special adaptations to xerophytic conditions. These adaptations result chiefly in the development of special water-holding cells or tissues in certain parts of the leaf or stem. In *Spartina* large colorless water-cells, called bulliform cells, are found at the bottom of the grooves of the upper surface of the leaf. The stomata are situated along the slopes of the groove and when the bulliform cells give up their water the grooves close up, thus preventing in a large measure the further escape of water through the stomata. Strands of stereome and a thickened and rugose cuticle are common in the graminaceous xerophytes.

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* Solereder, H. Systematische Anatomie der Dicotyledonen, 877, *f. 184*. 1899.

Spartina cynosuroides though an inhabitant of meadows and marshes is capable of growing on the sand plains, as it is found at Montowese. The microscopic anatomy of the leaf shows this grass to have a typical xerophytic structure as pointed out by O'Brien.* The roots have developed large lacunes (*pl. 27, f*), which primarily were probably for purposes of aëration. It is doubtful if these lacunes can be of any use to the plant under xerophytic conditions.

Andropogon scoparius exhibits a well-marked xerophytic structure, as special water-cells occur on the upper surface of the leaf (*pl. 26, g*). The same may be said of *A. furcatus*, which has a similar though less fully developed xerophytic structure of the leaf. The root structure of this plant compensates for what the leaf tissues may lack in reservoirs for the storage of water. A portion of the root is perennial and the thickened nodes are stored with starch for the nutriment of the plant the following season. The appearance of these thickened rhizomes and the cell structure of the small roots are shown on *pl. 27*.

Cenchrus tribuloides also shows a well-developed xerophytic structure in the leaf. *Sporobolus vaginaeflorus* likewise is well fitted by the structure of both leaf and root to inhabit desert places. Many water-holding cells appear in the leaf and the root is provided with a very thick-walled endodermis, especially in the small root. Large roots show a modification of the structure in favor of thinner walls.

The sedges examined have the inside wall of the endodermal cells very strongly thickened. This would seem to prevent the escape of moisture from the central cylinder to the outer portion in dry times, as the only means of transferring the moisture is through the pits. The sedges also have interesting structures of leaf and stem. *Stenophyllus capillaris* exhibits large water-cells on the upper surface of the leaf, which is almost reduced to linear. The stem is star-shaped in cross-section with stereome strands on the points and water-cells and stomata in the grooves. *Cyperus filiculmis* (*pl. 26*, *d*) has very large bulliform cells over the midrib, and when these cells lose their water the leaf folds. It also has a corm or tuberous root which is closely packed with starch and is doubtless a storehouse for both food and water. A very different leaf structure is found in *Carex Pennsylvanica* and *C. Muhlenbergii*, both inhabitants of the sand plains. Instead of the epidermal cells being very large for holding water there are several strands of colorless thin-walled cells running through the interior structure of the leaves between the mestome bundles. Though these strands seem to be regarded as lacunes, and in fact are called lacunes by most writers, they are not true lacunes, as they are spanned by delicate and undulating cell-walls in most of the material examined. In some cases these were broken down, but this might readily have occurred in cutting the hand sections. The writer considers these strands as internal water-storage tissue.

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* O'Brien, MSS. (see fifth footnote on p. 585).

In his "Report on a Botanical Survey of the Dismal Swamp Region," Kearney mentions the rosette form of *Linaria Canadensis*.* Certain other biennials like *Verbascum Thapsus*, *Onagra biennis* and *Artemisia caudata* exhibit the rosette habit during the first year and is doubtless of some value in preventing a loss of water through transpiration. The habit of these four species was observed by the writer on the North Haven sand plains.

But it is the annual plants with shallow root-systems, and having a short period of growth, that must suffer most in a time of severe drought. Such plants have woody roots in which the primary structure disappears early and the vessels are large and numerous. Annual legumes are of this class, and the roots of *Cassia Chamaecrista*, *Crotalaria sagittalis* and *Strophostyles helvola* show a number of large vessels in the secondarily thickened roots.

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* Kearney, T. H. Contr. U. S. Nat. Herb. **5**: 386. 1900.

Strands of sclerenchyma in the cortex are commonly found in these plants and are thought to be of value in strengthening and preserving the shape of the plant in excessive drought and wilting of the tissues. In size and number of vessels the root structure of *Trichostema dichotòmum* is similar to that of the annual legumes, but the sclerenchymatous strands are wanting. *Polygonum Convolvulus*, *Ambrosia artemisiaefolia* and *Sarothra gentianoides* have even larger vessels than the plants just mentioned, and seem to have nearly reached the limit of power to supply water to the upper portion of the plant.

In the small lateral roots of perennial composite plants we find much cortical tissue of colorless cells that can doubtless store water to be used later by the plants. Moreover, the plants of this family whose roots were studied inhabit dry regions. This is true of *Chrysanthemum Leucanthemum*, *Chrysopsis falcata*, *Ionactis linariifolius*, *Artemisia caudata* (biennial), *Solidago nemoralis*, *Antennaria neglecta*, *Gnaphalium obtusifolium* (*G. polycephalum*) and *Leptilon Canadense*.

In *Salomonia biflora* and *Vagnera racemosa* the endodermis of the small roots is interrupted or has some of its cells replaced by thin-walled cells opposite the points of the xylem as they appear in cross-section. This arrangement seems to provide for the transfer of water between the xylem and the cortex.

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YALE UNIVERSITY.

Explanation of Plates

PLATE 23

a. Tufts of *Andropogon scoparius* at North Haven. Most of the trees are black oaks (*Quercus velutina*).

b. A patch of *Baptisia tinctoria* at Montowese. Scattered about are plants of *Lespedeza capitata* and *Asclepias Syriaca*, while in the foreground the ground is covered with young seedlings of *Trichostema dichotomum* and *Sporobolus vaginaeflorus.*

PLATE 24

a. General view at North Haven, showing black oaks (*Quercus velutina*) growing in the sand.

b. A mound of milkweeds (*Asclepias Syriaca*) at Montowese. Between the plants are young seedlings of *Sporobolus vaginaeflorus.* The mound is about two feet higher than the level of the surrounding sand.

PLATE 25

a. A carpet of *Sarothra gentianoides* at North Haven. A red cedar stands in the foreground at the left and in the left middle distance may be seen a crescent-shaped mound of *Aronia arbutifolia.* In the middle distance at the right is a bunch of *Andropogon furcatus.*

b. View at Montowese showing how the sand has been blown away leaving the roots exposed. The mound is four or five feet higher than the level of the surrounding sand and the vegetation is red cedar (*Juniperus Virginiana*), black oak (*Quercus velutina*) and poison ivy (*Rhus radicans*).

c. Red cedar (*Juniperus Virginiana*) at North Haven, showing the effects of winds and storms in blowing and washing away the sand and exposing the roots.

PLATE 26

a. Transverse section of leaf of *Polygonella articulata*, showing epidermal layer of water-cells and central water-holding tissue. The assimilating cells occupy the space between the epidermal layer and the central tissue. *as*, assimilating tissue; *g*, glandular cell. × 70.

b. Transverse section of the median portion of the leaf of *Carex Muhlenbergii*, showing the strands of water-tissue inside the leaf. *w*, water-tissue; *m*, mestome bundle; *st*, stereome strand. × 36.

c. Portion of epidermal layer from leaf of *Ionactis linariifolius* showing peculiar thickening of the cuticle and a protected stoma. *cu*, cuticle; *s*, stoma; *p*, projection of the cuticle showing opening into cell. × 325.

d. Transverse section of leaf of *Cyperus filiculmis* showing water-cells on upper surface and tannin ducts. *w*, water-cells; *t*, tannin ducts. × 70.

e. Cross-section of median portion of leaf of *Syntherisma sanguinalis.* *e*, epidermal layer of water-cells supported over midrib by about three others of similar tissue; *st*, stereome; *m*, mestome bundles; *h*, hairs. × 70.

f. Transverse section of leaf of *Stenophyllus capillaris.* *w*, water-cells of upper surface; *st*, stereome strands; *s*, stoma. × 175.

g. Transverse section of the median portion of a leaf of *Andropogon scoparius.* *w*, water-cells of epidermal layer; *m*, mestome bundles. × 70.

h. Hairs from leaf of *Helianthemum majus.* × 70.

PLATE 27

a. Transverse section of a portion of the root of *Cyperus filiculmis*, showing single vessel in the center and thick-walled endodermis. *v*, vessel; *e*, endodermis; *cor*, cortex. × 550.

b. Section of small root of *Sporobolus vaginaeflorus*, showing endodermis with inner walls much thickened, thick-walled pericycle and very large cortical cells. × 175.

c. Transverse section of a portion of a large root of *Sporobolus vaginaeflorus*, showing four large vessels in the central portion. *v*, vessel; *p*, pericycle; *e*, endodermis with wall thickened but less so than in small root; *cor*, cortex. × 175.

d. Transverse section of the root of *Andropogon furcatus*, showing vessels, endo dermis, central and cortical tissues. *c*, central cells mostly filled with starch; *e*, endodermis with inner walls of cells thickened; *cor*, cortex; *v*, vessel. × 115.

e. Gross appearance of rootstock of *Andropogon furcatus*, showing thickened nodes. Reduced.

f. Transverse section of a portion of the root of *Spartina cynosuroides*, showing lacune. *l*, lacunes; *r*, root-hairs. × 70.

PLATE 28

a. Transverse section of small root of *Salomonia biflora* (*Polygonatum biflorum*) showing 6-rayed xylem with endodermal layer interrupted opposite the xylem points. Also the great development of water-holding cells in cortex. × 70.

b. Transverse section of a root of *Trichostema dichotomum* in which secondary thickening has taken place. The vessels are large and numerous. No sclerenchyma-cells in the cortex. × 70.

c. Transverse section of secondarily thickened root of *Polygonum Convolvulus*. The vessels are extremely large. A few strengthening cells in the cortex. × 70.

d. Transverse sections of secondarily thickened root of *Crotalaria sagittalis*. The vessels are large and numerous, and sclerenchyma-cells are abundant in the cortex. × 83.

The Tissues of Some of the Plants of the Sotol Region

By William L. Bray

The opening of the desert botanical laboratory of the Carnegie Institution at Tucson, Arizona, with its facilities for studying the environmental conditions and the life phenomena of desert vegetation, marks an appropriate time for beginning a revival of the study of the tissues of desert plants. During the period of great activity of the study of plant structures as related to environment, say, from 1880 to 1895, desert plants — at any rate xerophytic plants — were especially selected because of the very striking adaptive phenomena exhibited in their organs and tissues. The literature of the period abounds in noteworthy contributions to our knowledge of the structure of desert plants, and their means of adaptation to their environment, of which perhaps the most noteworthy was Volken's "Flora der aegyptisch-arabischen Wüste" (1887), although in the more general ecological works, such as Haberlandt's "Physiologische Pflanzenanatomie" (1884; ed. 2, 1896), Warming's "Lehrbuch der ökologischen Pflanzengeographie" (1896; original Danish ed., 1895) and Schimper's "Pflanzen-geographie auf physiologischer Grundlage" (1898), the structures of desert plants have supplied many of the most instructive and interesting examples in adaptation phenomena.

During this active period, the various ecological forms and the more numerous adaptation devices in xerophytes were described, so that for us there would now seem to remain little to say as to the effect of desert environment upon the form or habit of plants, and upon the structure of various tissues such as epidermal, assimilation, absorption, etc. As a matter of fact, however, very few of the ecological forms of our American desert vegetation have been embraced in a special physiologic-anatomical study, and besides, progress has been made, meanwhile, in the study of physiological processes in plants, so that it would appear reasonable to expect helpful results from a renewed study of tissues of desert plants in the light of the most recent physiological knowledge. If the vital phenomena in such a type as the star-cactus (*Ariocarpus fissuratus*), for example, were under investigation, it is very certain that these could not be made fully clear without a very accurate and detailed knowledge of the machinery through which they operate, *i. e.*, the various tissue systems in the organism. It is in just the unique — in a sense pathological — types like this and various other Cactaceae, Yucceae, Agaveae and others that the study of vital processes will be keenest, and these also are just the types in which the study of the tissues from the physiological point of view gives the greatest zest.

Since the study is distinctly a physiologic-anatomical one, the classification of tissues on the basis of function will be the preferable one as indicated in Haberlandt (*l. c.*) — for example, assimilation tissue will embrace cells whose main function is that of carbon assimilation, regardless of whether they are morphologically the cortex of a stem or the mesophyl of a foliage leaf or the superficial zone in a leaf of a succulent type such as *Agave.* But it is always to be noted what morphological parts have become devoted to certain functions, as that of assimilation, since it is desired to know why the cells of certain topographical regions of a plant have been chosen for this or that function.

In the present instance a study has been begun upon the tissues of a few of the most specialized of the ecological forms occurring in the very arid or desert region of Trans-Pecos Texas — a region which in this and in a subsequent geographic-ecological paper is designated the "Sotol Country," because of the predominance of the Sotol or *Dasylirion Texanum* upon the most characteristic parts of the region. From the breaks of the Devil's River westward across the Pecos and beyond to the front ranges of the Rocky Mountain system and far southward in Mexico, is a vast limestone region well advanced in the progress of erosion, consisting of high conical hills and long ridges or divides with even slopes and with wide draws leading finally into deep-cut canyons such as those of the Pecos and Rio Grande and numerous side branches. This great area is thickly strewn with coarser or finer limestone débris resulting from the weathering of the soft upper part of the formation. There is no rich soil-covering to hide the rocks, and the vegetation is the scant and open formation characteristic of rocky steppes (Felsensteppen), in this case made up of Yucceae, Agaveae, Cactaceae and desert shrubs like *Covillea*, *Flourensia*, *Koeberlinia*, *Fouquieria* and various Mimoseae. That is the typical Sotol area. As a matter of fact, this kind of formation occurs on most other foothills and mountain slopes westward, and especially in the Great Bend region, whether the geological formation be limestone or not, so long as there is the unstable covering of stony débris.

It would not be accurate to class all such country as desert, although the Great Bend region is as much so as the Sahara itself; but it is all a region in which plant life is beset by extreme environmental conditions such as the following:

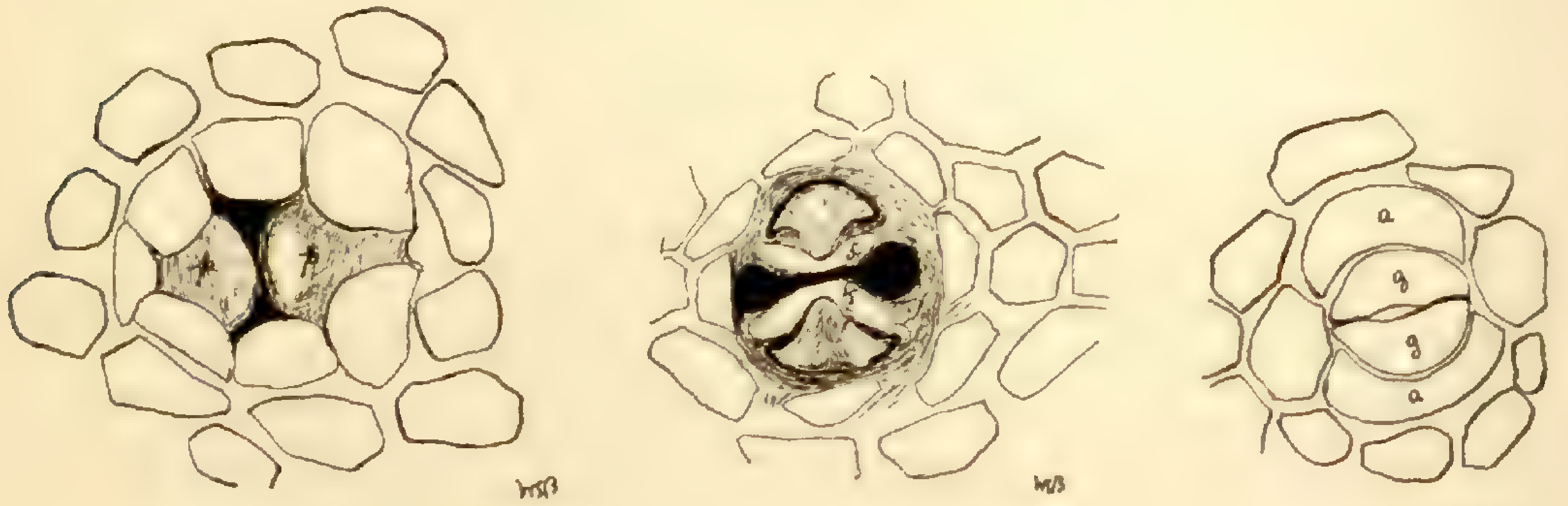
A precarious rainfall of fifteen to nine inches annually; an evaporation capacity in the air equal to from six to ten times the annual precipitation; strong and constant dry winds; a dry, arid, stony soil; intense and prolonged illumination, heightened by the glare of the stony earth and by the altitude and the vaporless air; intense heating of the air, the stony earth and the plant bodies growing therein, in this respect approximating the maximum insolation endured by plant life in any region.

The species, of which only the tissues concerned in transpiration are described in this paper, were taken from the vicinity of Langtry on the Rio Grande near the mouth of the Pecos; but all of them abound in the most extreme conditions of the Great Bend region and elsewhere.

1. *Agave Lecheguilla.* This is one of the less succulent-leaved agaves. The long, hard, spiny points of the leaves and their hard margins constitute a large proportion of mechancal tissue, the leaves being narrow and pike-formed because of the development of this tissue. The plant is, however, possessed of ample storage capacity for erecting a flowering stalk eight to twelve feet tall and one to two inches in diameter at base. The epidermis (*f. 4, cu*) consists of long, columnar cells with a heavy cuticular layer and great thickness of water storage cellulose like *Frankenia bracteata* of western Australia and the South African aloes. At the junction of the epidermis and the underlying assimilation tissue, the walls of each are rather thick, thus binding the two more firmly together and preventing the tearing loose of the epidermis

during the strain incident to alternate contraction and expansion. The cells of the assimilation zone are more or less palisade in arrangement and somewhat elongated, becoming interior-ward more nearly isodiametric and again thicker walled with numerous pits and large intercellular areas. Here, it is no longer assimilation but storage tissue.

The stomata are the specially interesting structures, naturally, since to them is entrusted the precarious function of opening a channel of communication from the external environment to the delicate interior tissues, a fact equally true of each of the other species. The guard-cell apparatus of the stomata appears in surface view very much like that of numerous other Liliiflorae, the guard-cells proper being partially surrounded and held in place by the very much larger auxiliary cells (*f. 3*). But the protective apparatus above these is quite peculiar and different from any types with which the writer is familiar. Exterior-ward, where the stomatal pit opens upon the surface, two prominent projections of the epidermal walls fore-and-aft almost meet midway and block the passage except for two triangular entrances right and left (*f. 1*). Below this, two more complex projections from right and left again almost meet midway, leaving the merest slit at right angles



1 2 3

Agave Lecheguilla.

FIG. 1. Surface view of stoma, showing the stomatal pit blocked by two projections *p, p,* fore-and-aft.

FIG. 2. View of stoma shown in *f. 1* obtained by focusing on horizon immediately below 1. Projections from right and left block the passage by a compressed funnel-like structure (*f, f*) seen in cross-section in *f. 4*.

FIG. 3. The guard-cell apparatus lying below horizons 1 and 2. Obtained by removing thin tangential section of epidermis. *g, g,* guard-cells; *a, a,* auxiliary cells. The orientation and magnification of the stoma is the same in the three figures.

to the one above, and with two openings, this time fore-and-aft, and so alternating with the upper (*f. 2*). This inner arrangement is as if one were to take a rubber funnel and pinch the sides together midway (*f. 4, f, f*), leaving the margins otherwise flaring (*f. 4, f'*). Below the slit-like neck then, the tube of the funnel should expand bulb-like, thus representing the still-air space immediately over the guard-cell apparatus (*f. 4, sc*). Manifestly, such a device is well calculated to hinder direct communication

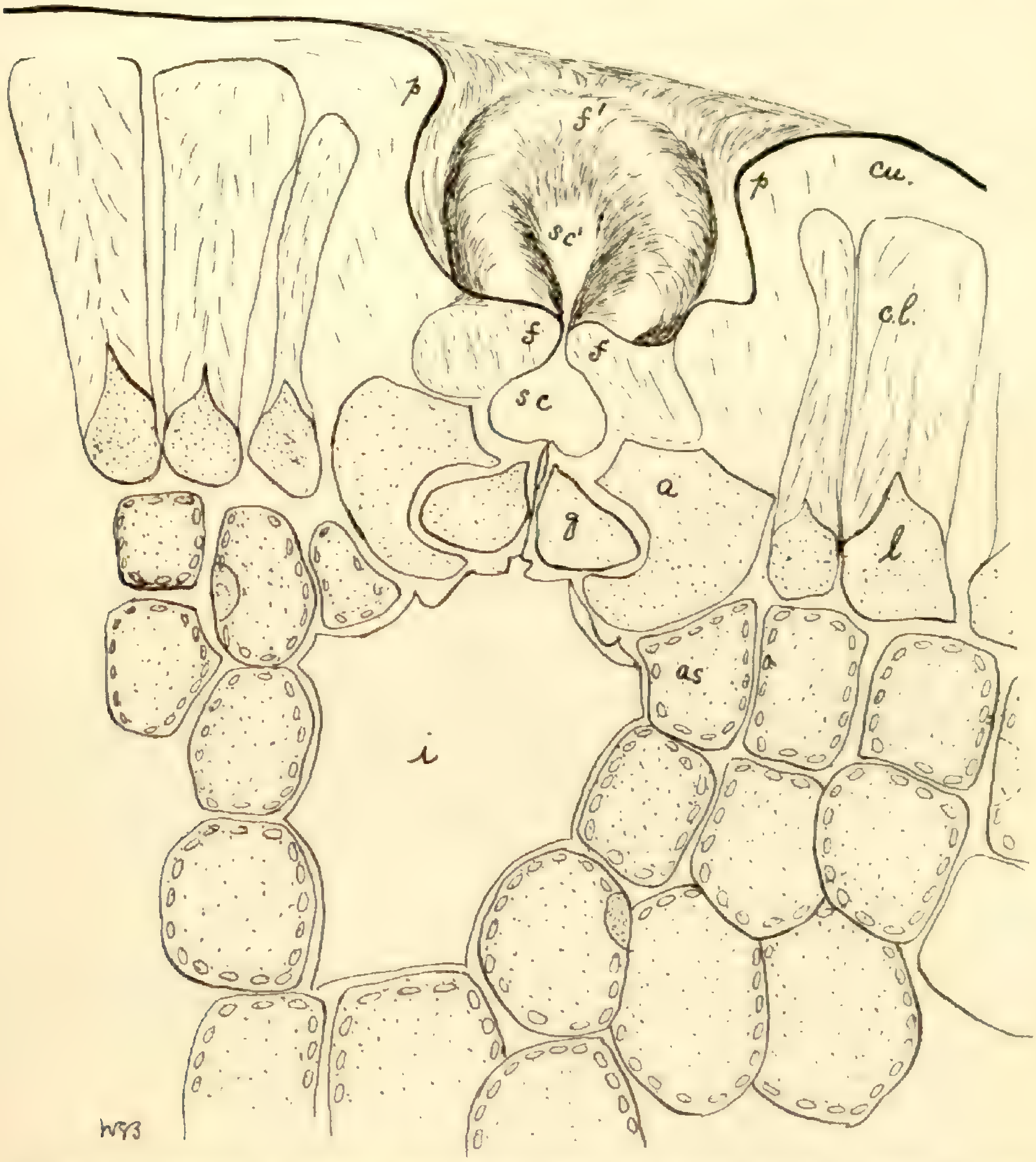


FIG. 4. Transverse section through superficial portion of leaf of *Agave Lecheguilla*. *cu*, cuticular layer of epidermis; *c.l.*, the cellulose layer; *l*, cell-lumen; *p*, *p*, rim of stomatal pit, which becomes a prominent projection above *f'*—the fore-and-aft projections seen in *f. 1*; *f*, *f*, section of the inner projection with free margin at *f'*, the narrow median slit opening below into the still-air chamber, *sc*, which has wider communication through *sc'* (compare *f. 2*); *as*, assimilation tissue; *i*, the large, substomatal air-chamber.

between interior and exterior and so fortify the plant against dangers entailed in such an exchange in so arid a climate. The air-chamber beneath the guard apparatus (*f. 4, i*) is relatively large and has ample connections by many channels with adjacent chlorophyl-bearing cells.

2. *Hesperaloe parviflora.* — This *Yucca*-like plant has relatively soft and succulent leaves as compared with the true yuccas, and with *Nolina*, to which it would appear to have some genetic relation judging from the identity of stomatal structures. The long

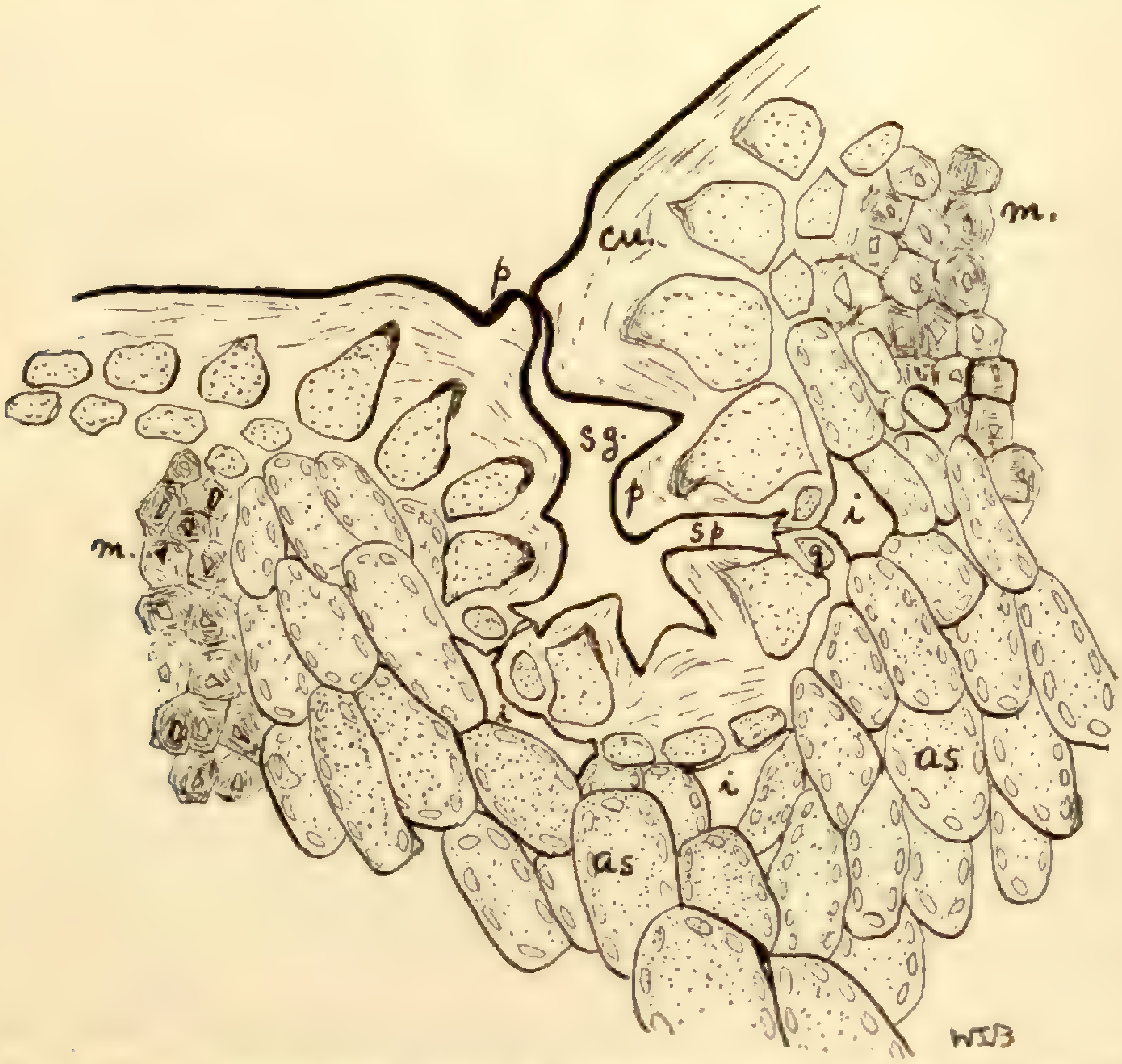


FIG. 5. Transverse section through superficial part of leaf of *Hesperaloe parviflora*. *sg*, stomatal groove; *p, p*, the blocking projections; *sp*, the stomatal pit; *m*, portion of bast-like mechanical rib; other abbreviations as before.

and rather slender and flexible leaves are longitudinally grooved and ridged, the grooves (*f. 5, sg*) providing a favorable location for the development of stomata, and the intervening ridges being ribs of bast-like, mechanical tissue (*m, m*). In the case of *Nolina* (*f. 6, m, m*) these ribs pass completely across the narrow diameter of the leaf, while in *Hesperaloe* they reach perhaps less than one third the distance across.

The rather deep grooves (*f. 5, sg*) widen out at the bottom, thus making a still-air chamber which is cut off from too free communication with the outside by the development of very numerous overlapping finger-like processes (*p, p*) equivalent to the hairy investment of stomatal pits in some plants. From the bottom and deeper sides of the groove, the stomatal pits proper (*sp*) descend through a thick epidermal wall to two very simply arranged and apparently rather immobile guard-cells (*g*) beneath which is an intercellular chamber (*i*) leading by various small channels to adjacent assimilation cells (*as*).

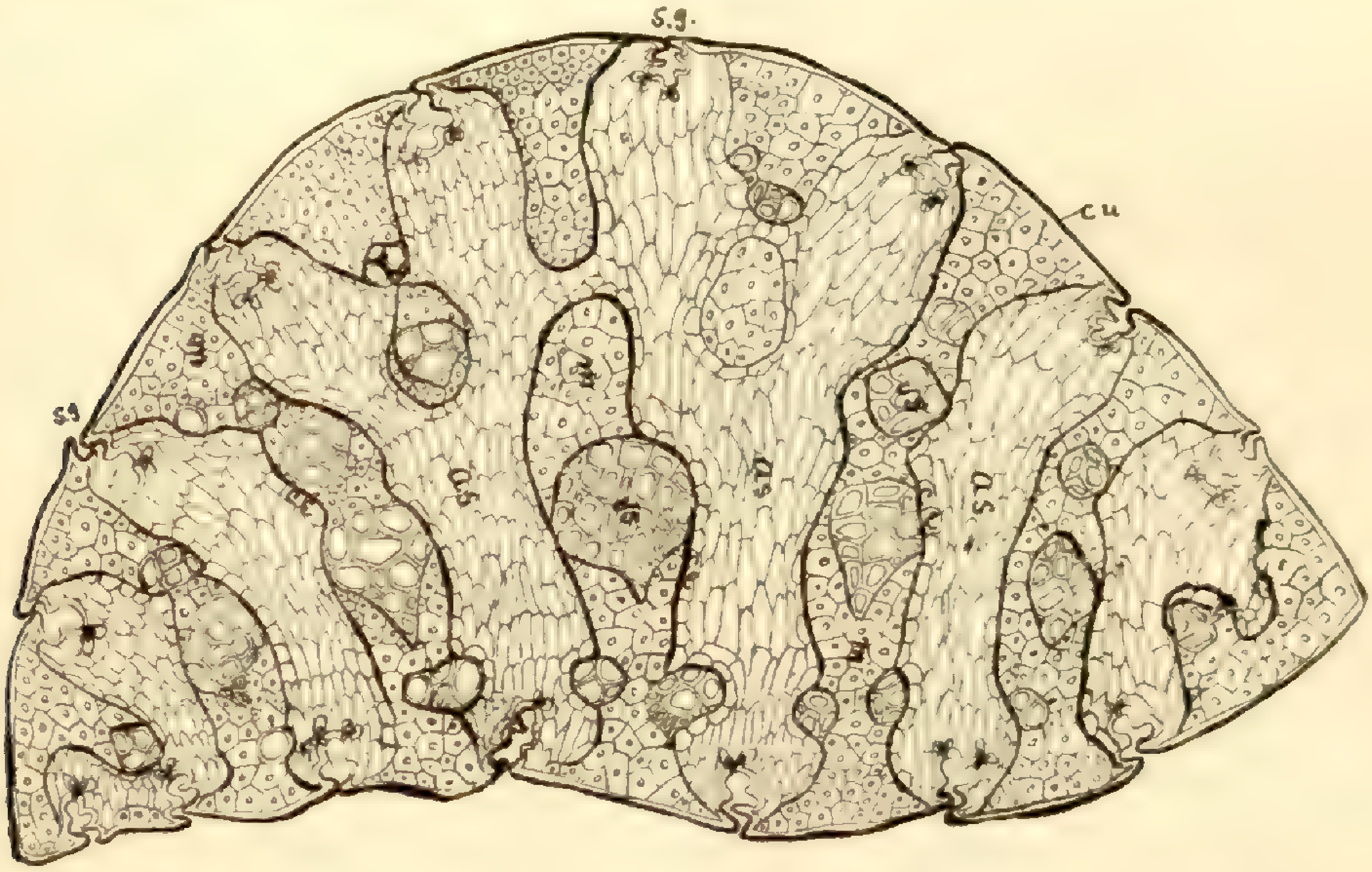


FIG. 6. Transverse section of leaf of *Nolina Texana*. *m, m*, girders of bast-like mechanical tissue enclosing the vascular conducting strands, *vs*, and alternating with bands of assimilation tissue, *as*; *ce*, sheath of non-chlorophyl-bearing (transportation?) cells investing the bast areas; other parts as above. × ± 25.

The assimilation tissue is, as one would expect, arranged with reference to the grooves, showing in cross-section a somewhat V-shaped zone of cells arranged along the sides of the groove and reaching from its bottom interior-ward to the apex of the V, gradually becoming isodiametric, thicker walled, storage-cells with much pitted walls.

3. *Nolina Texana.* — In the case of *Nolina*, the leaves are long, linear and grass-like, though rigid. They possess almost no storage tissue in the interior and the mechanical ribs extend across the leaf as girders (*f. 6, m, m*) separating the assimilation areas (*as*), which also reach across the thin diameter. Thus the

leaf is marked lengthwise by alternating bands of mechanical and assimilation tissue. The conducting tissue (*f. 6*, *vs*) is enclosed in the bands of mechanical bast-cells. In *Nolina* also the epidermis (*cu*) has very thick, rigid walls and plays an important part as mechanical tissue.

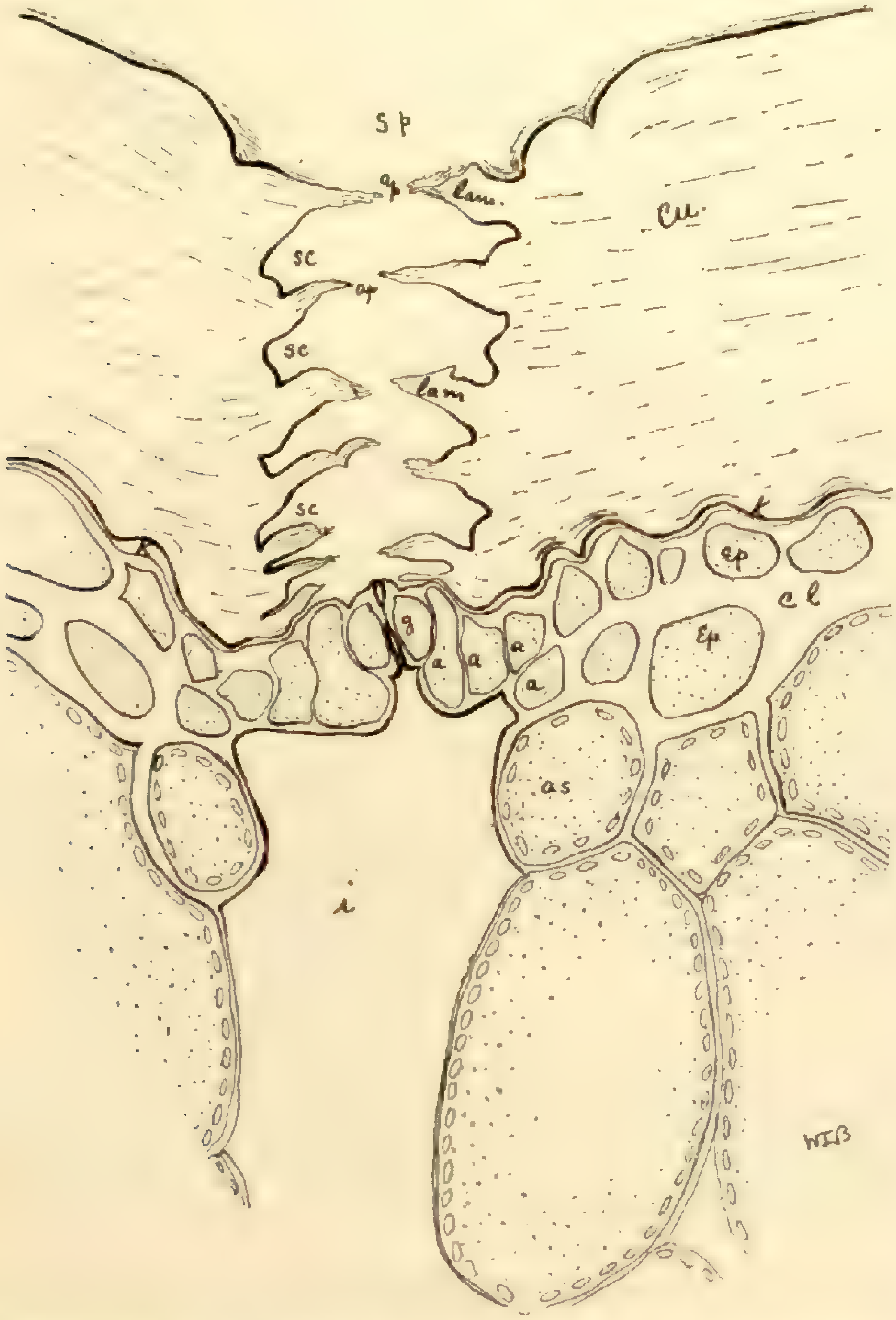


FIG. 7. Cross-section of epidermal region of *Ariocarpus fissuratus*, transversely through a stoma. *ep*, the double-layered epidermis with heavy binding wall, *cl*, and greatly developed cuticular (chitin-like) layer *cu*; *sp*, the stomatal pit leading down to the guard-cell apparatus, *g*, *a*, *a*, *a*, and interrupted by numerous diaphragm-like outgrowths, *lam*, with apertures, *ap*, so placed as to make a sort of spiral; *sc*, the successive still-air spaces; *k*, line of rupture between cellulose and cuticular layers of epidermis.

4. *Ariocarpus fissuratus* (*Anhalonium fissuratum*) commonly called the star-cactus and living-rock cactus, has a fleshy turnip-shaped body growing almost hidden in the dry adobe and with the exposed part so dusty gray as to be difficult to distinguish

from the loose rocks among which it grows. This exposed part consists of numerous imbricated triangular-pyramidal horny lobes from the axils of the interior of which the flowers arise. These lobes display the assimilation tissue and are in addition storage organs. The significance of the horny exterior is that of an external skeleton, which is the special need of a succulent body lying exposed to the crushing force of passing animals and shifting stones. This skeleton is so firm that the exposed part of the plant embracing the lobed portion retains its normal shape even after all the succulent part has disappeared from rotting, drying up or being eaten away by small animals. This chitin-like skeleton is a secretion of the epidermis which becomes many times as thick as the epidermal cells proper and is striated, showing the progressive thickenings (*f. 7, cu*). It is rather clear or like ground glass. Between the fissures and at the point of the lobes, this secretion is especially thick and horny. It is interesting to compare this tough epidermal secretion with that in the following type, *Euphorbia antisyphilitica*, which appears to arise in the same manner and is similarly striated, but is an easily frangible, soluble wax.

The epidermal cells proper are very small and form two irregular layers (*f. 7, ep*). This irregular arrangement together with the thick cellulose walls of these (*cl*) and the outermost assimilation cells, aids in binding the chitin-like layer more firmly. In spite of this, the whole skeletal covering becomes rather easily separated from the epidermal cells in the older parts (*f. 7, k*).

The stomatal opening is a very deep pit leading directly from the surface through the thick cuticle (*f. 7, sp*) to the guard-cell apparatus, the cells of which are in a depression somewhat below the general level of the epidermal layers (*f. 7, g, a, a*).

From the walls of the stomatal pit arise several stories of smaller outgrowths (*f. 7, lam*) stretched diaphragm-like across the pit, but perforated toward the center (*ap*) to allow the passage of gases. These perforations in the successive lamellae are so placed as to make a spiral zigzag passage for gases, from within outward or conversely. Not infrequently, a section shows a nautilus-like spiral of these lamellae and their apertures. By this remarkable device is the movement of gases hindered by a series of still-air chambers, and so excessive transpiration checked.

The guard-cell apparatus seems to consist of five or six pairs of auxiliary cells in addition to the usual guard-cells proper, giving a flexible arched covering to the large air-chamber beneath.

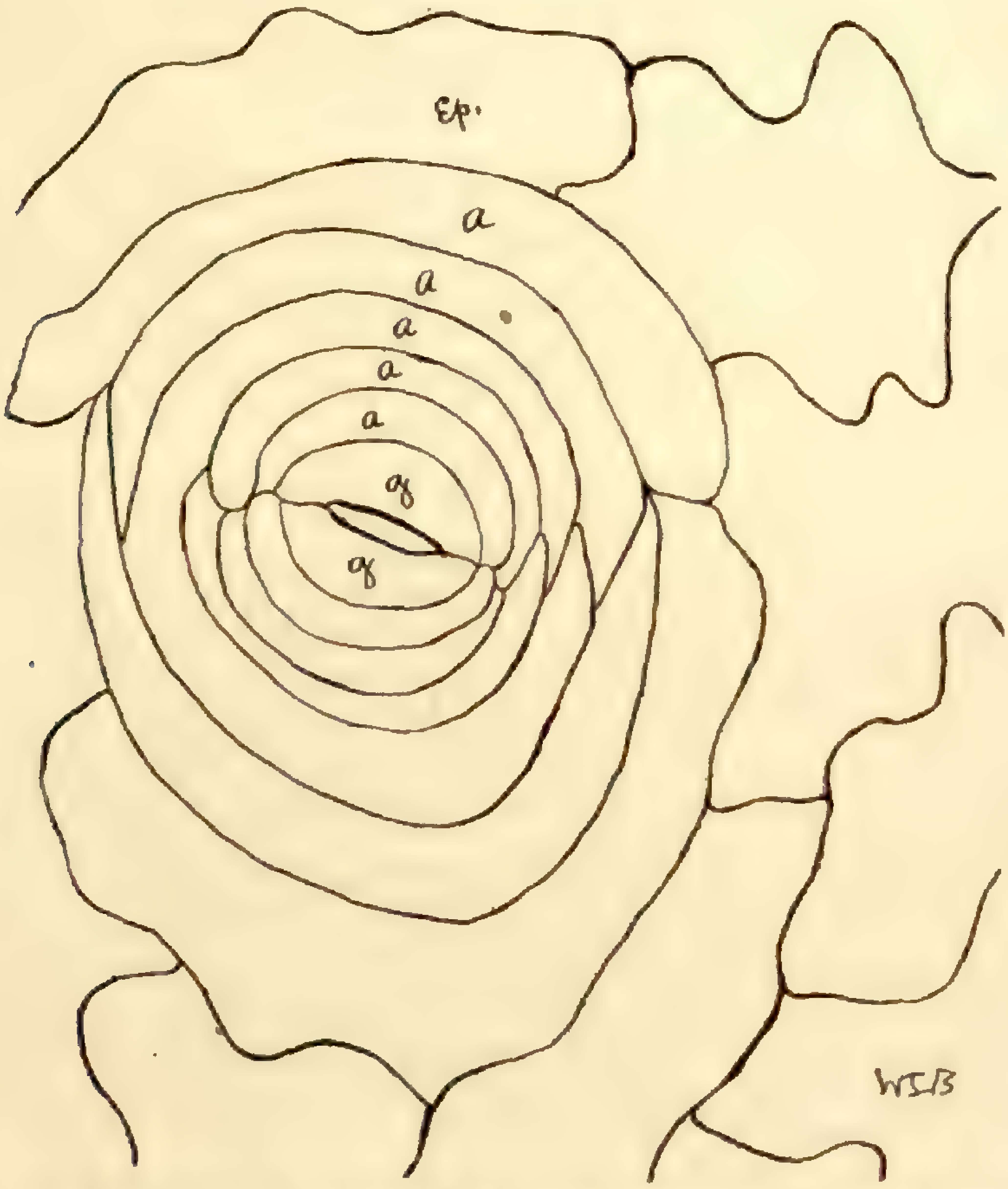


FIG. 8. Surface view of stomata like that shown in *f. 7*, after removing the cuticular layer. *g*, *g*, the guard-cells; *a*, *a*, etc., the five pairs of auxiliary cells; *ep*, the epidermal cells proper.

The cells of the assimilation zone are very large and arranged palisade-wise for several layers, becoming, then, spherical, thick-walled and much pitted storage-cells.

5. *Euphorbia antisyphilitica.* This is a leafless *Euphorbia* with the habit of an *Equisetum.* It occurs in very great abundance amongst the rocky débris of the hills and mountain slopes of the Great Bend region, especially in the Terlingua district, and is plentiful in some spots as far down the river as the mouth of the Pecos.

In general, the plant shows a moderately thick-walled epidermis thickly coated with wax (*f. 9, ep, wa*), which is clear and marked by minute longitudinal furrows on younger stems, but which becomes white and broken by fissures on the old stems. Beneath the epidermis is a thick zone of cortical assimilation perenchyma with cells elongated radially in the manner of palisade (*f. 9*, *as*). Toward the vascular cylinder, which, because of the great thickness of the cortex, appears to have the central location as in roots, the assimilation-cells gradually become more nearly isodiametric, thicker-walled and pitted storage-cells. Within the vascular cylinder is an ample pith-region in which the cells are branched and disconnected so as to form almost a trabecular tissue (*f. 10*, *arm*, *i*).

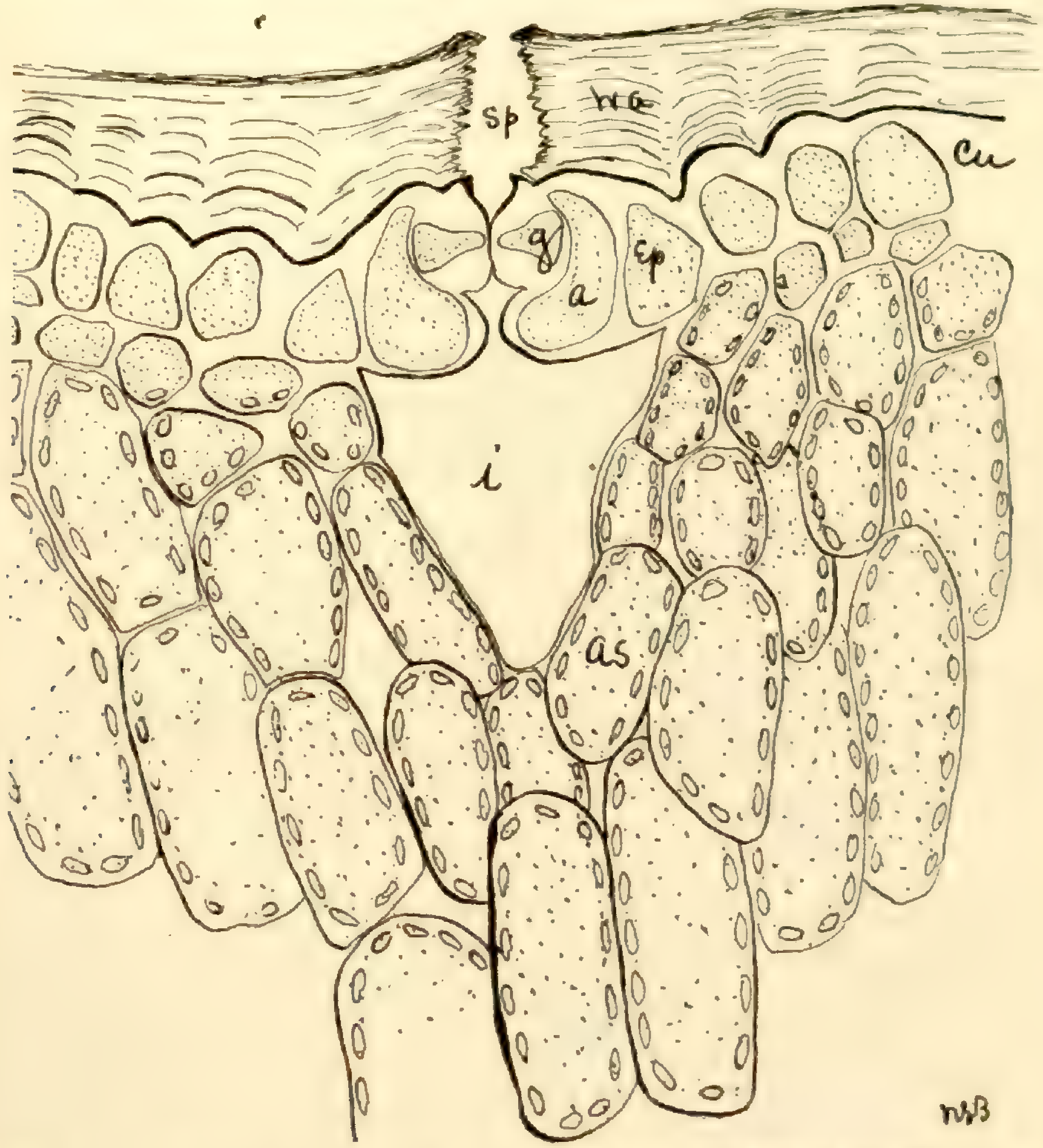


Fig. 9. Cross-section of young stem (1 yr.) of *Euphorbia antisyphilitica*, transversely through a stoma. *wa*, the heavy waxy secretion of the epidermis perforated at *sp*, by crater-like opening above the guard-cell apparatus, *g*,*a* ; other lettering as before.

Viewed from the surface, the stoma appears as a crater-like opening through the waxy covering, the wax being elevated about the pores, volcano-like. On younger stems it is easily observed that the stomata are more or less grouped or run in diagonal or spiral clusters following certain wavy depressions in the stem. When the stem is perfectly turgid these depressions are faint, but with the approach of wilting they become more prominent. It appears that in this emergency the stomata would be depressed farther below the surface. Very interesting is it to examine a young wilted stem in which the stomata all lie at the bottom of the wrinkles caused by wilting. It would appear evident that the tissue beneath the stomata is less firm than elsewhere and as a matter of fact a superficial tangential section reveals that the sub-stomatal assimilation-cells are irregular, making 2, 3 or 4 way connections with other cells and so giving rise in effect to a limited spongy mesophyl.

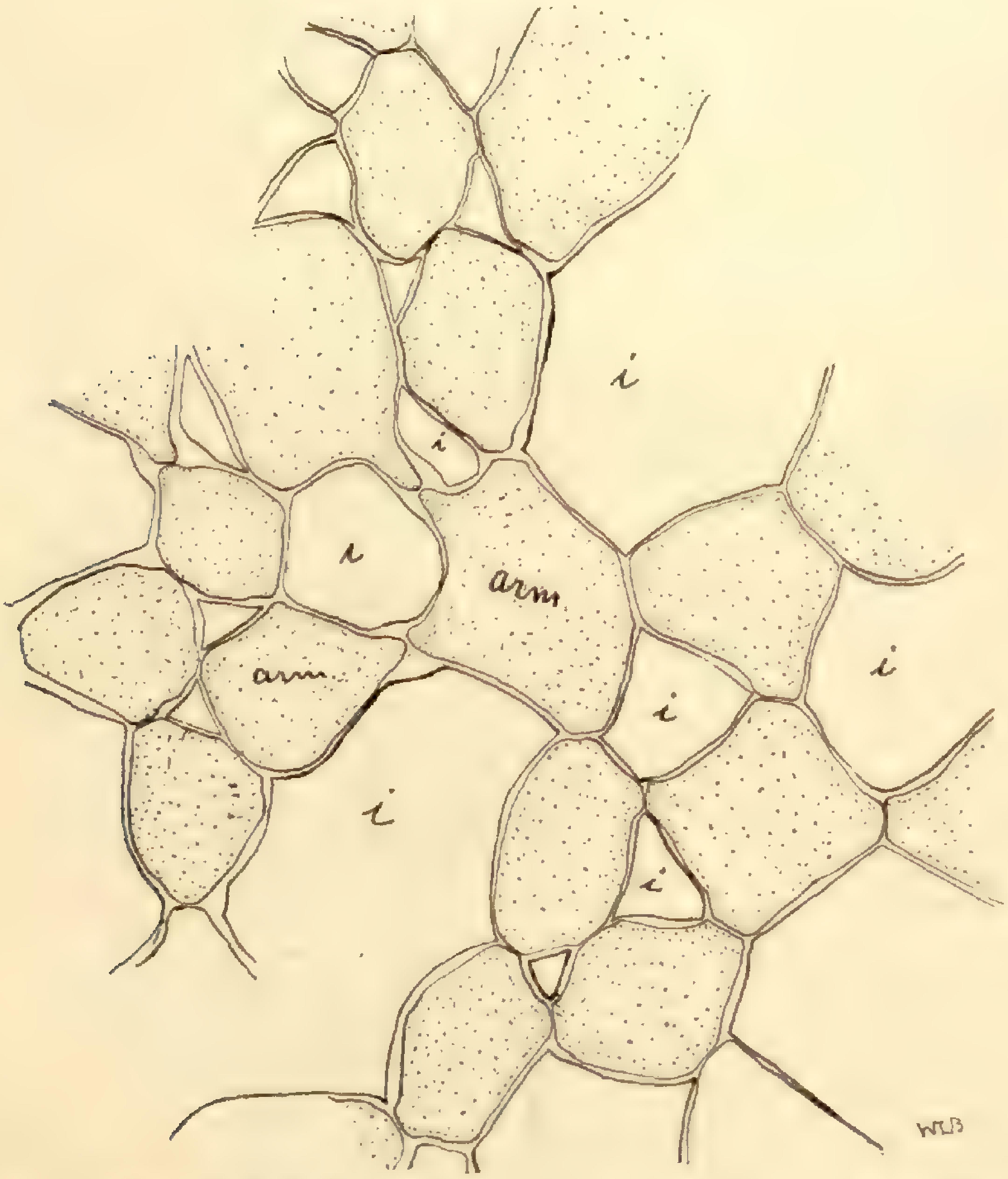


FIG. 10. View of portion of pith-area seen in cross-section of *E. antisyphilitica*; *arm*, the irregular pith-cells with numerous projecting arms giving lateral connection across larger or smaller intercellular passages, *i*,*i*, etc.

The waxy covering appears to be a secretion of the epidermal wall. It is added layer by layer, the striations remaining distinct (*f. 9*, *wa*) even when the covering is old and fissured. Structurally, there is much in common with the chitin-like cuticle of *Ariocarpus*, even the interruption at the stomatal pits showing a tendency of certain striae to continue across, diaphragm-like. It is distinctly waxy, however, and soluble in alcohol.

The epidermal cells themselves are small as in *Ariocarpus* and occupy about two irregular layers (*f. 9*, *ep*). Here, also, the walls of these and of the first underlying assimilation-cells (*f. 9*, *cu*) are notably thickened to give a firmer binding of the epidermis to the remaining tissues which the stress of alternating turgidity and flaccidity would tend to disrupt. The outer epidermal cells, at least, are ordinarily elongated with the stem-axis, but about the guard-cell apparatus they become box-shaped and more or less concentrically placed, forming a saucer-like depression at the bottom of which lies the guard-cell apparatus. The guard-cells proper are small and held in place above the ample air-chamber by two very large auxiliary cells which partially embrace the former (*f. 9*, *g*, *a*).

This stomatal structure recalls the case of *Euphorbia Tirucalli* of Zanzibar, figured by Haberlandt (Physiologische Pflanzenanatomie, *f. 162*, 1896), in which the appearance of young branches, the waxy covering, the stomatal apparatus and the crater-like openings in the wax above the stomata are all very similar to *E. antisyphilitica*, but Haberlandt's figure appears to be diagrammatic merely, since the waxy covering is not so conspicuously built up, but only a slight elevation above the general surface of the thick coat as shown in *f. 9*.

UNIVERSITY OF TEXAS.

Three New Willows from the Far West*

By O. von Seemen

Salix Franciscana

A large shrub with spreading branches: twigs brown, with short gray pubescence: petioles 1.5 cm. long or less, similarly pubescent; leaf-blades cuneate-oblong to obovate, 10 cm. long or less, 4 cm. wide, with a short point, entire, the upper surface sparsely, the lower more densely gray-pubescent (this short pubescence dense on both sides of young leaves at the apex of shoot), the upper surface dark green, scarcely shining, the lower a dull gray-green; midrib and wide-meshed nervature slightly prominent above and sharply so beneath; stipules feebly developed, semi-cordate, obtuse, serrate, with short gray pubescence: aments appearing before the leaves, erect; the subtending scales brown, with short gray pubescence; pedicels short, with dense similar pubescence and bearing small lanceolate to oblong leaves which are densely gray silky pubescent beneath and on the margins: staminate aments long-cylindric, 6 cm. long or less, 1.7 cm. thick, narrowed toward apex, somewhat curved, dense-flowered; axis with short, dense, gray pubescence; bracts oblong, obtuse, narrowing to base, upper half brown, the lower light, with dense, shaggy, gray pubescence; stamens 2, united at the base or half way up, smooth, about twice as long as the bract; anthers slender, yellow; gland 1, posterior, narrowly ovate, truncate, not more than half the length of the bract: pistillate ament cylindric, 3 cm. long or less, 1 cm. thick, somewhat curved, dense-flowered; axis like the staminate; bract oblong, apex round, base narrowed, upper half dark brown, lower light, densely shaggy gray pubescent, reaching the lower part of the capsule: capsule stipitate (stipe half the length of capsule and smooth), narrowing from a narrowly oval base, smooth; style about half as long as the stipe; stigmas short, emarginate, capitate; gland 1, posterior, narrowly ovate, truncate, as long as the stipe.

The Cliff House, San Francisco; among sand hills along the coast. (C. F. Baker, Plants of the Pacific Slope, *no. 303*, March 14 and Sept. 1, 1902.)

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*[Through the kindly interest of Dr. E. B. Copeland, of Stanford University, it becomes possible to present these descriptions in English instead of German. Specimens illustrating these species were distributed in the spring of 1903 under these names to all the greater public herbaria of the world, and besides to many private herbaria. — C. F. Baker.]

Salix Bakeri

Tree or shrub 5–10 m. high: twigs dark brown, smooth, but the young tips with very short sparse gray pubescence: petioles not over 0.5 cm. long, with very short gray pubescence; leaf-blades lanceolate or spatulate-lanceolate, 6 cm. long or less by 1.5 cm. wide, acute, the basal half narrowed to the petiole and acute (leaves at base of branches with the apex round with a short point), entire or very shallowly serrate with minute teeth, with very short gray pubescence, the upper surface becoming smooth, bright green and shining, the lower bluish green and dull; midrib slightly prominent on the upper, strongly so on the lower surface; nervature wide-meshed, depressed from the upper surface, slightly prominent beneath: aments appearing before the leaves; the subtending scales dirty yellow-brown, with sparse, short, gray hairs: staminate aments erect, with very short peduncles (clothed with dense, short, light gray hairs and bearing minute, light gray-pubescent, bract-like leaves), cylindrical, 3 cm. long or less, 1.2 cm. thick, somewhat curved, dense-flowered; the axis with dense, short, bright gray pubescence; bracts obovate, apex rounded, the upper half dark, the lower light, brown, bearded with long light gray hairs; stamens 2, free, smooth, not over three times as long as the bract; anthers oval, yellow; gland 1, posterior, narrowly subulate, one half the length of the scale or less: pistillate aments erect, pedunculate like the staminate, cylindrical, 5 cm. long or less, 1 cm. thick, somewhat curved, dense-flowered; axis like the staminate; bracts oblong, almost truncate, in other respects like the staminate; capsule with a smooth stipe two thirds its own length, flask-shaped with narrowly ovate base, apex with short gray hairs; style not over one third as long as the stipe; stigma short, forked, emarginate; gland 1, posterior, narrowly subulate, not over one third as long as the stipe.

Foothills near Stanford University, Santa Clara County, California. (C. F. Baker, Plants of the Pacific Slope, *no. 274*, March 9 and May 10, 1902.)

Salix Ormsbyensis

A low, spreading shrub, with short, ash-gray, smooth branches: petioles 5 mm. long, or less, smooth, or sparingly short-pubescent when young; leaf-blades lanceolate, 4 cm. long or less, 1 cm. wide, acute, the base obtuse, entire or finely serrate, smooth (only the young leaves silky beneath), both surfaces light green; midrib and nerves slightly prominent; stipules not well developed, semiovate, acute, finely serrate, smooth; aments appearing with the leaves, with yellowish green, smooth subtending scales, erect, the short peduncle clothed with short gray hairs and bearing small, lanceolate, entire or finely serrate, smooth or scantily pubescent leaves; staminate ament oval or short-cylindrical, 2 cm. long or less, 7 mm. thick, somewhat narrowed toward the apex, dense-flowered; axis beset with long, light gray, curly hairs; bracts oval, contracted below, apex obtuse or round, the upper half brown, the lower light, the base densely and the surfaces sparsely clothed with long, light gray, curly hairs; stamens 3, or sometimes 2 in the upper part of the ament, two or three times as long as the bract, the lower half bearing scanty, long, light gray, curly hairs; anthers oval, yellow; glands 2, posterior, ovate, truncate or divided, half as long as the bract; pistillate aments erect, stalked like the staminate, short-cylindric, 22 mm. or less in length, 12 mm. thick, somewhat loosely flowered; axis like the staminate; bracts like the staminate, one third to one half as long as the stipe; the capsule stipitate, short-conical, from an oval base, obtuse, smooth; stipe longer than the capsule, smooth: style very short, thick; stigmas short, oval, retuse or divided, erect; gland 1, posterior, ovate, truncate or divided, one sixth to one fourth as long as the stipe.

King's Cañon, Ormsby County, Nevada, at 1700–2000 m. (C. F. Baker, Plants of Nevada, *no. 924*, June 1, 1902.)

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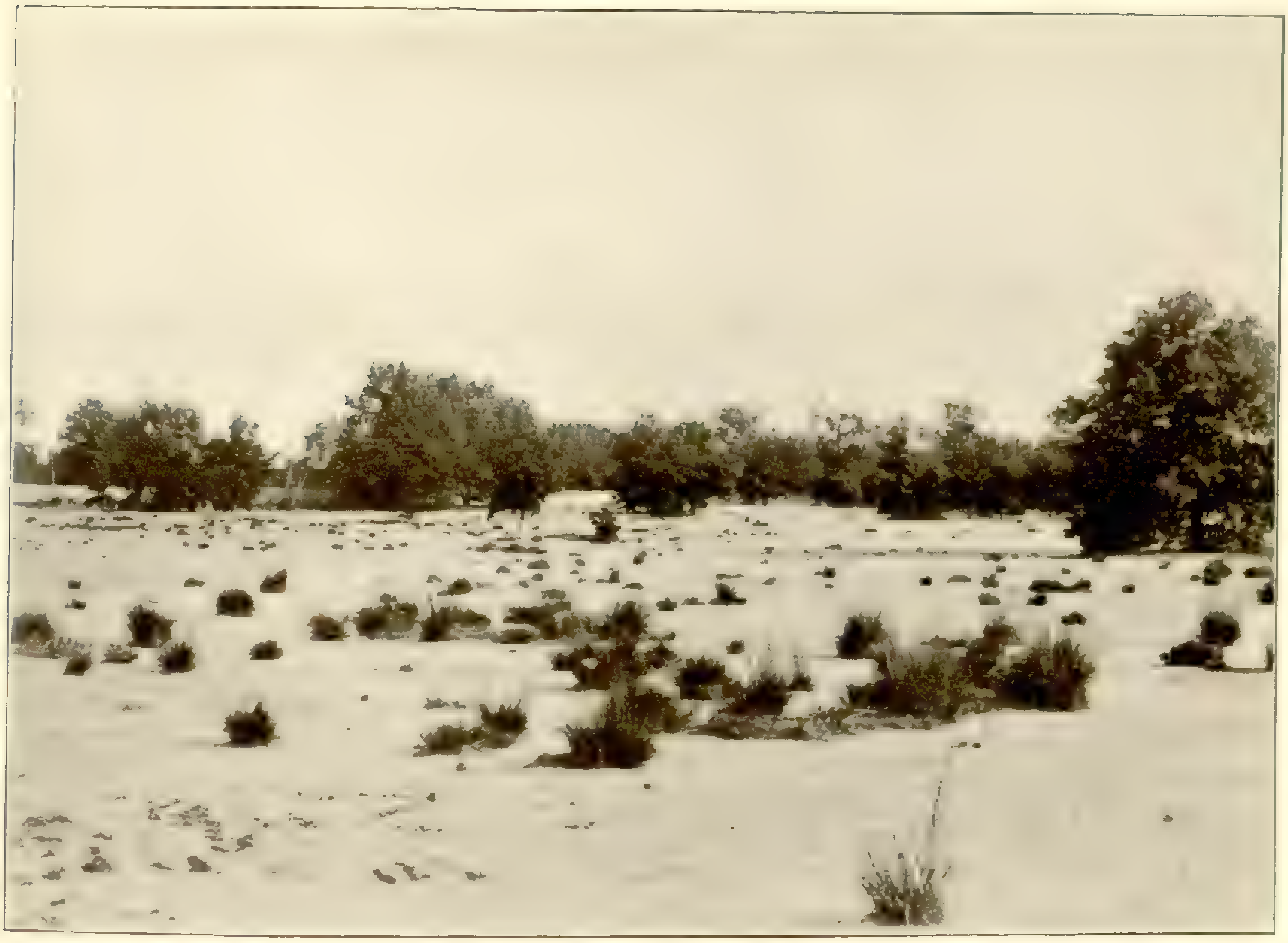
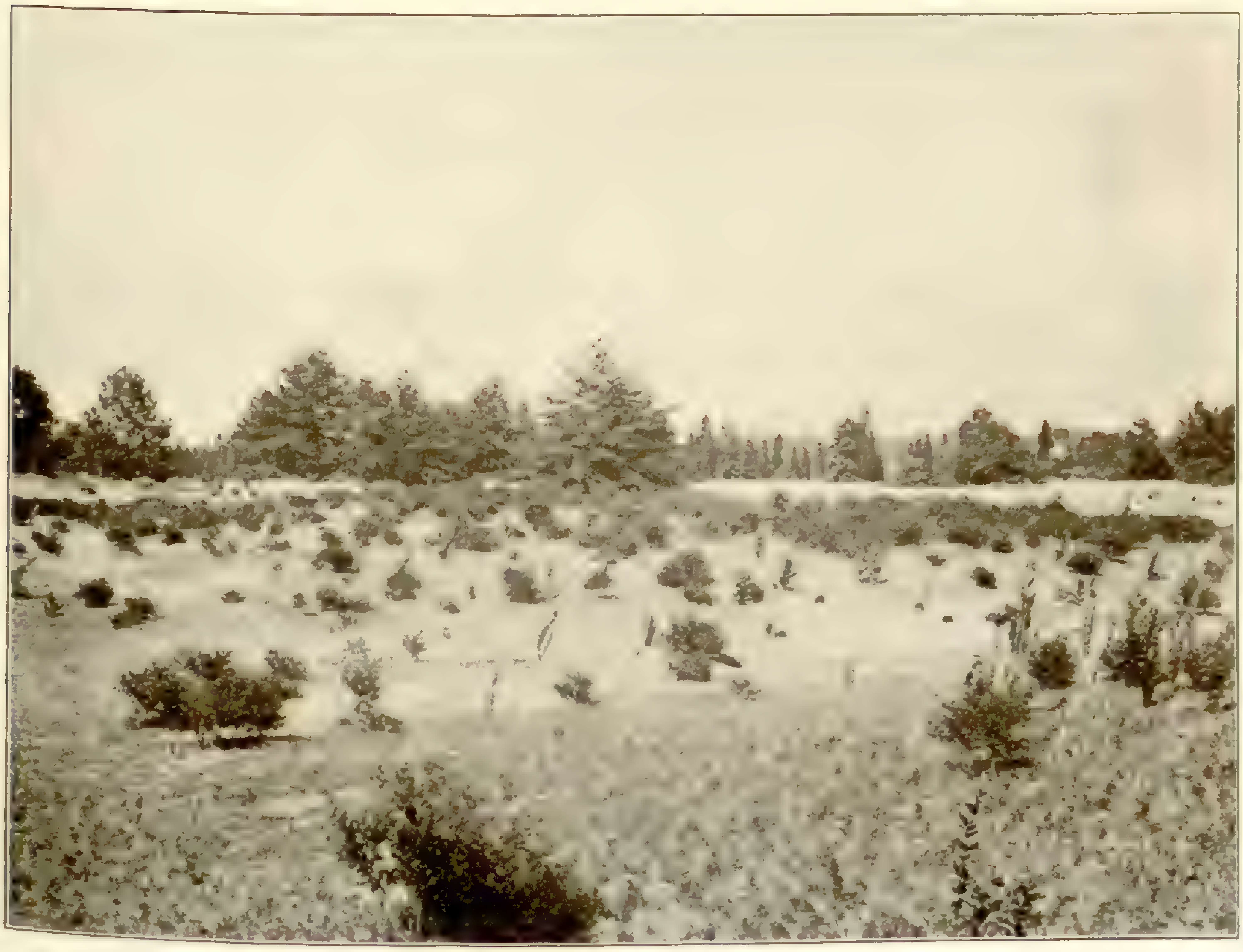


a. *Andropogon scoparius*, North Haven.



b. *Baptisia tinctoria*, Montowese.

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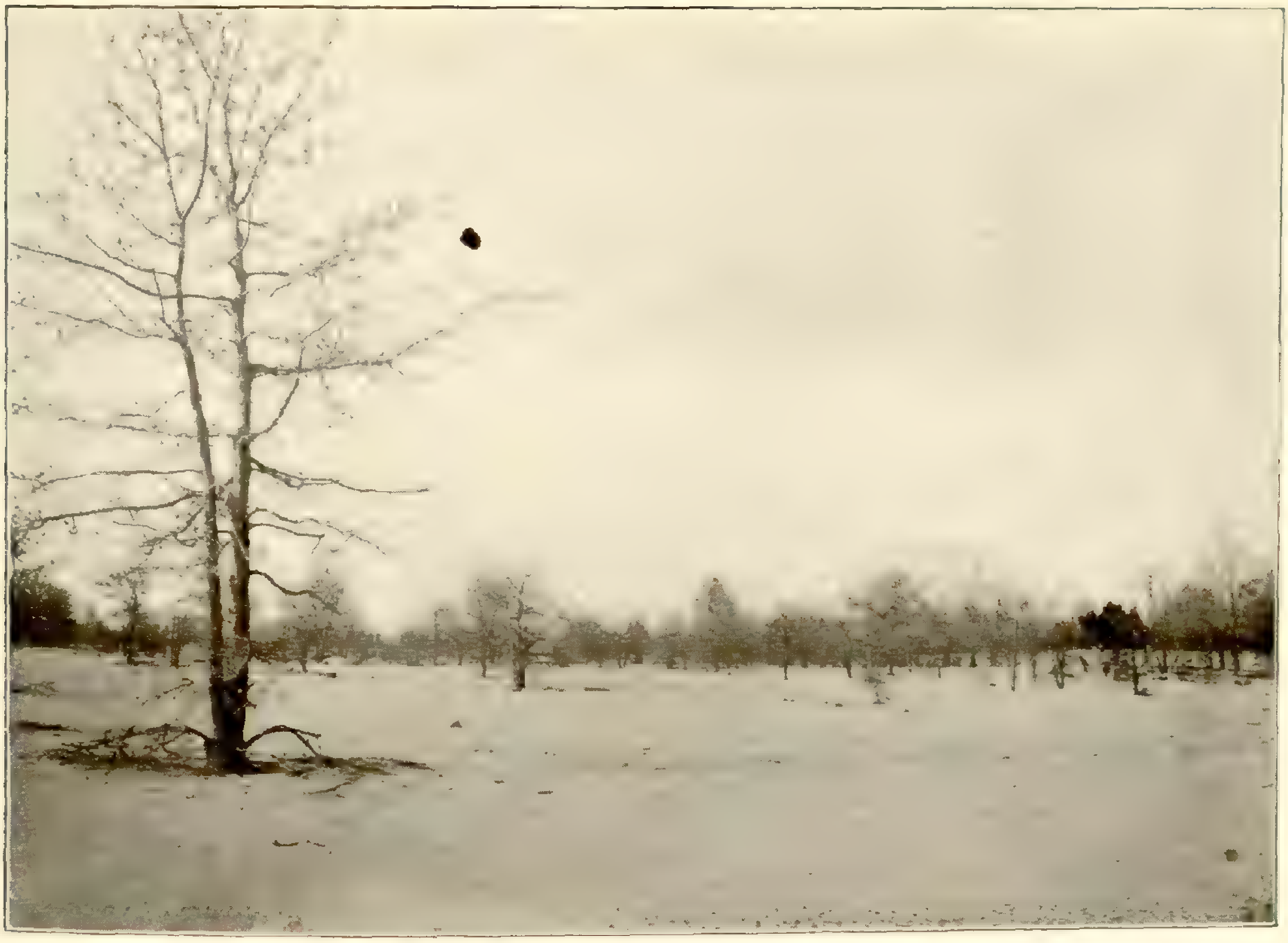
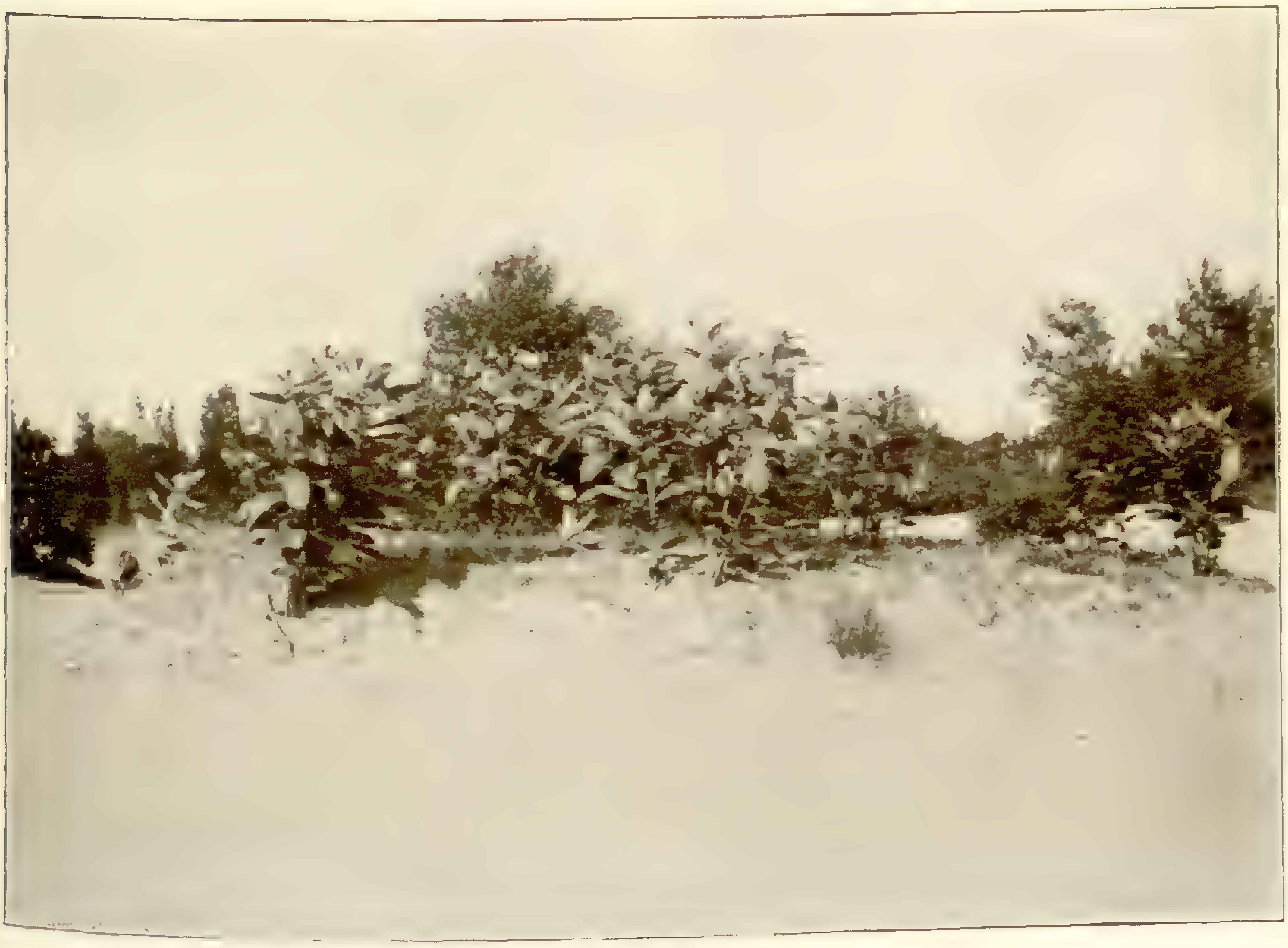


a. Black oaks at North Haven.



b. A mound of milkweeds, *Asclepias Syriaca*, Montowese

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a. A carpet of *Sarothra gentianoides*, North Haven.

b *c*

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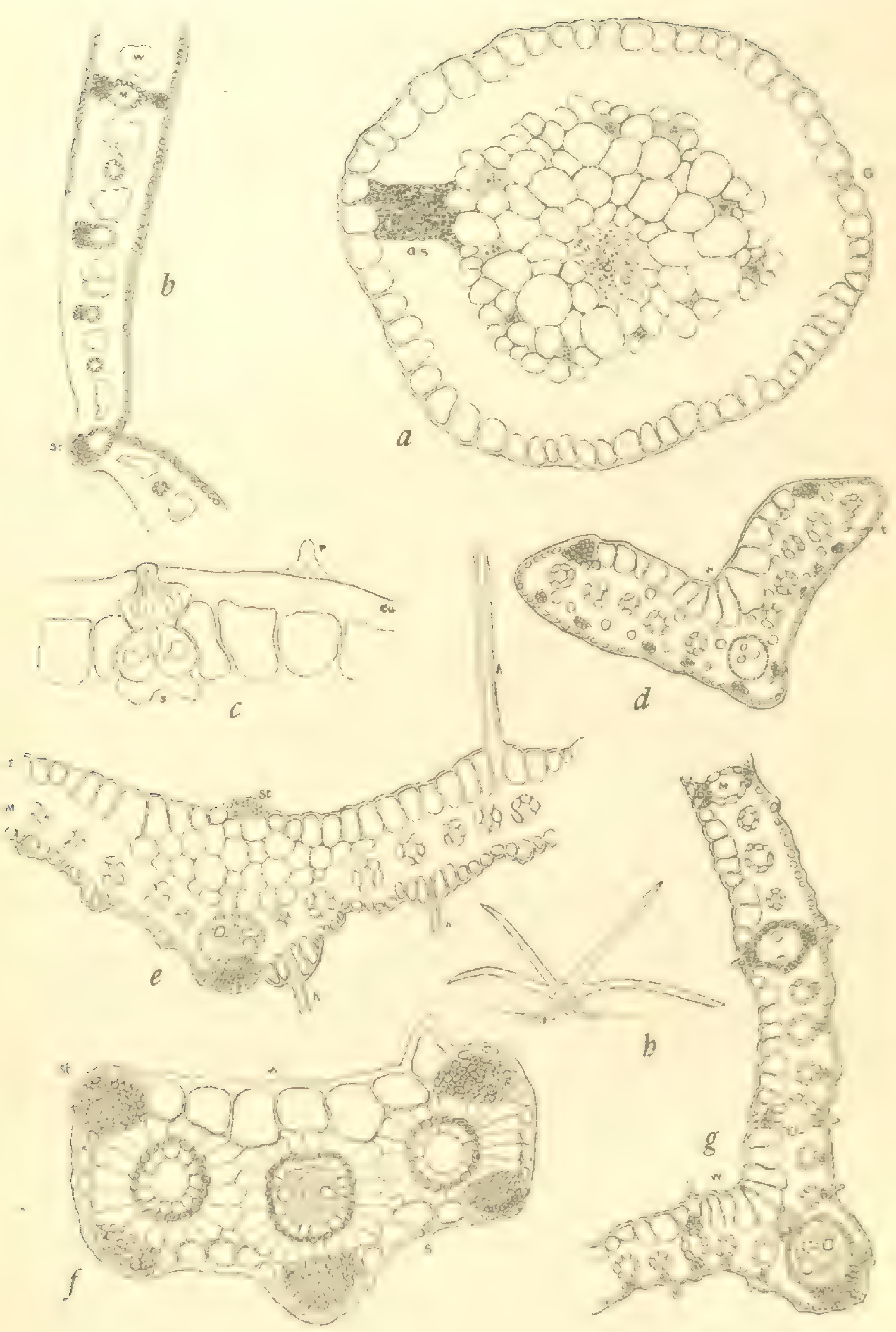
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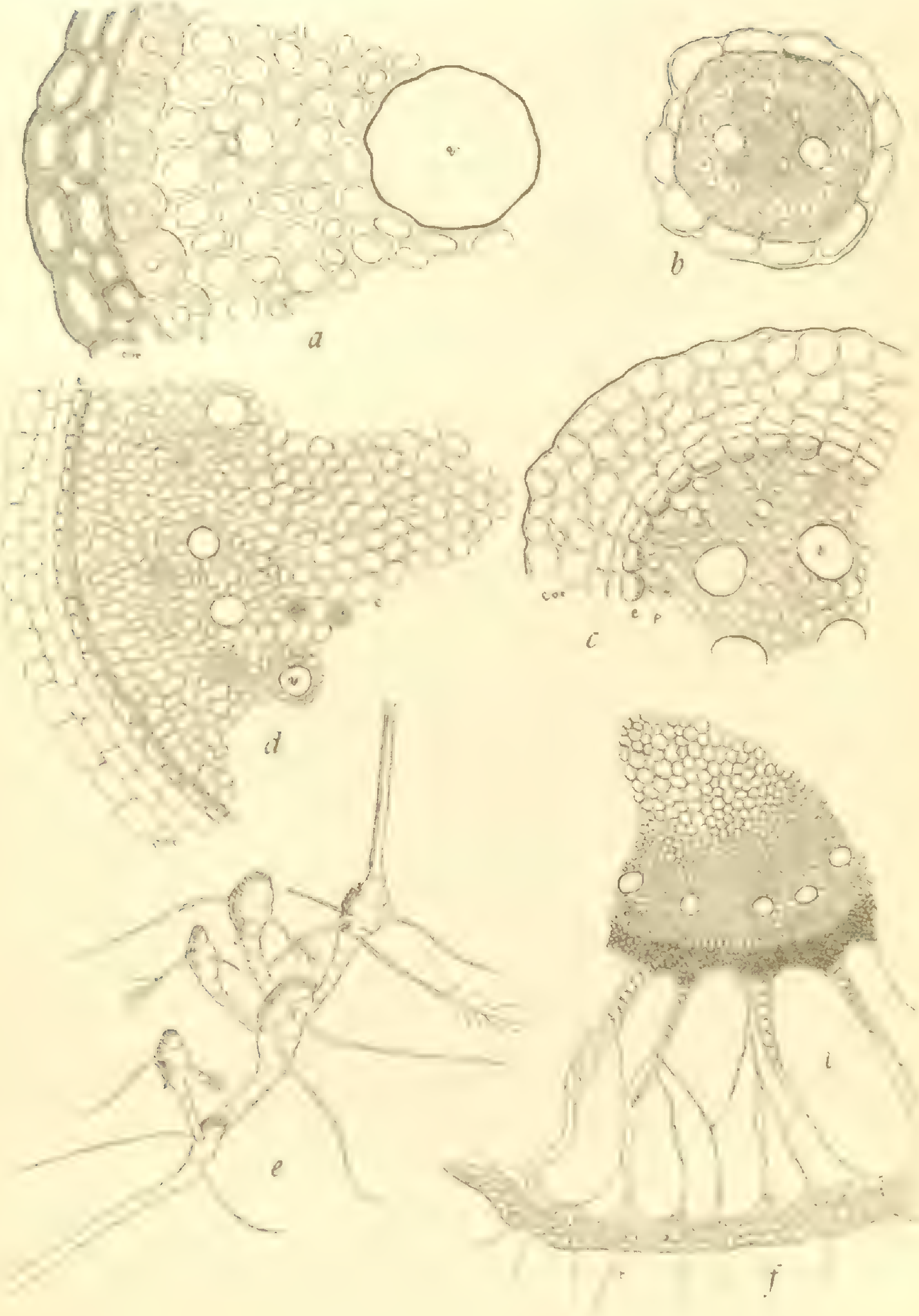
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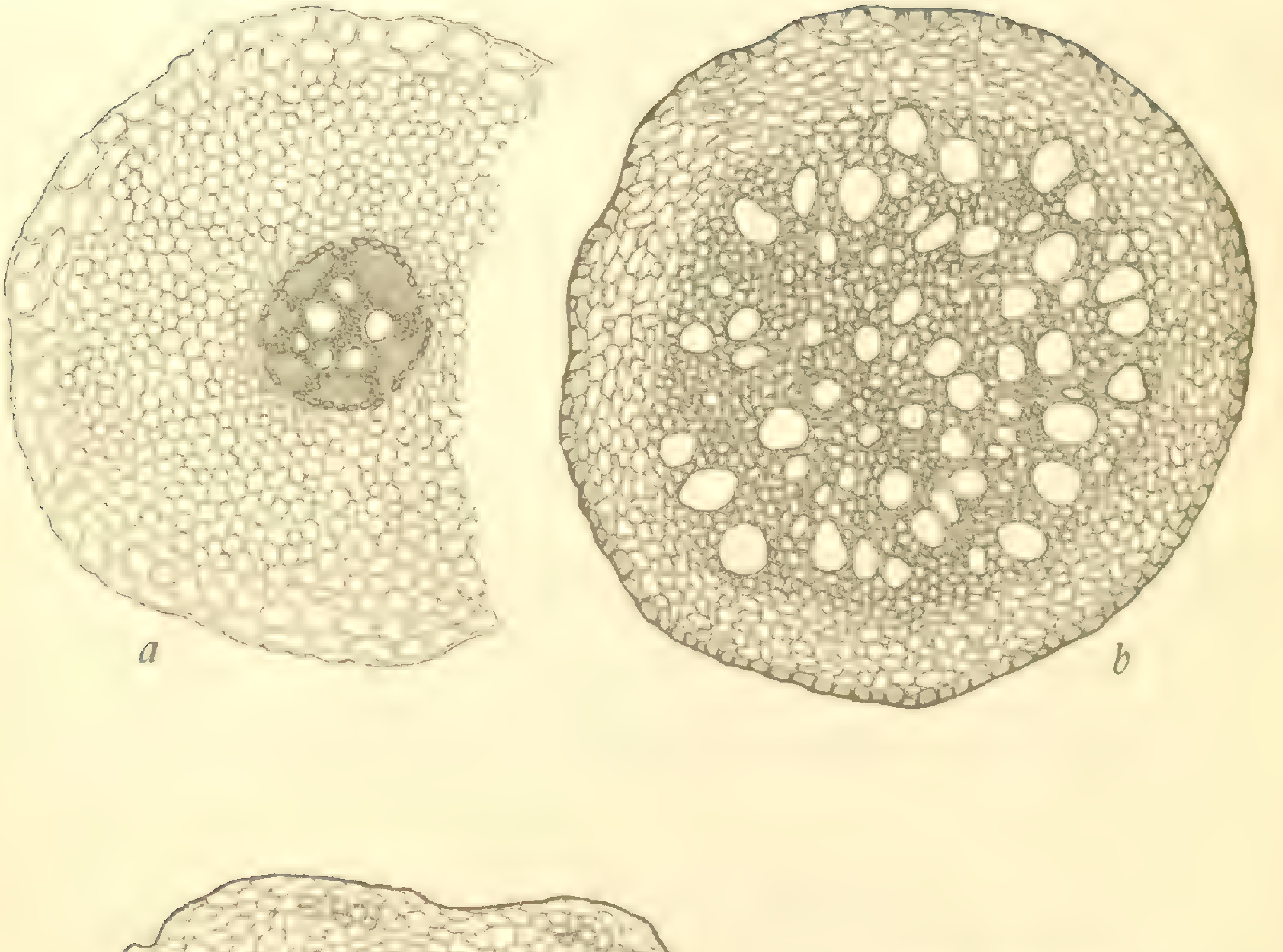

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Botanical Garden, Bronx Park, New York City.

Treasurer,
FRANCIS E. LLOYD
Columbia University, New York City.

Meetings the second Tuesday and last Wednesday of each month alternately at the College of Pharmacy and the New York Botanical Garden.

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On Some Species of Heliconia

By ROBERT F. GRIGGS

(WITH PLATES 29 AND 30)

Heliconia occupies in America the place in plant society that is filled by the banana and its congeners in the Old World tropics. Its anatomy is similar to that of its better-known relative. Like the banana it is a very difficult subject for the botanical collector. The parts are both thick and succulent and of such size as to make it impossible to represent the plant at all adequately on an herbarium sheet. As knowledge of plants from remote regions has been largely dependent on herbarium specimens, it is not difficult to appreciate that *Heliconia* has been an unsatisfactory genus to work on. Only once before the present study was undertaken has it been studied to any extent in the field. This fact accounts for most of the innovations suggested in the present paper.

Although the genus has been monographed several times within recent years, as far as practicable recourse was had to original literature in determination and comparison. Appended to the paper is a list of the papers consulted. It includes the original descriptions of twenty-six of the twenty-nine recognized species. Though no pretension is made to bibliographic completeness, it may serve as the beginning of a guide to anyone who desires to take up the study of the genus, as it is believed that with a few exceptions most of the important literature is cited.

All our plants, except the Porto Rican *Heliconia Borinquena*, came from a region in eastern Guatemala, which centers in Messrs. Owen and Champney's coffee *finca* Sepacuité, a few miles north of

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Senaju. From there trips were made northeastward to Cahabon and in a more easterly direction up the valley of the Oxec, a good-sized creek emptying into the Cahabon river ten miles below the town. In addition, the most abundant species at least were collected along the road from Panzos to Sepacuité. We were informed that the region had never been visited by a botanist, the nearest that one had been being Senaju, where Captain John Donnell Smith made a short stop. The mountains about Sepacuité, which is about 3,000 feet above sea-level, are heavily forested and in nearly their primeval condition. Here one species, *H. tortuosa*, is very abundant. Few of the species, however, are forest plants. Around the old Indian town of Cahabon the country has been reduced to an almost treeless, grass-grown desert, and on the edges of this desert where the woods are not very thick and yet the water-supply is sufficient, most of the species were found. Along the road from Panzos to Sepacuité much the same conditions prevail as around Cahabon.

We wish to express our thanks to the owners of Sepacuité, to Mrs. Owen especially, and to Mr. Alfred Rock, of Setzimaj, for their kind hospitality and for the very great assistance they so eagerly offered us, without which it would have been impossible to make our collections. I am very grateful to Mr. John Donnell Smith, of Baltimore, for the loan of all of his material on the genus, and to Dr. W. A. Kellerman, of the Ohio State University, for valuable criticism and suggestions. Thanks are also extended to the officers of the National Herbarium for the loan of specimens.

The references after the descriptions, *e. g.*, "*no. 258*," are to the collectors' numbers accompanying the sheets. Except where otherwise stated, all the plants are from a collection made by Mr. O. F. Cook and myself during March and April, 1902. This collection was made for the United States Department of Agriculture and is deposited in the herbarium of the department in the National Museum. The numbers of photographs cited are either serial or field numbers of the collection in the Office of Tropical Agriculture of the Department.

Key to the Groups and Species Discussed in this Paper

I. Leaves borne at intervals along an elongated stem, *i. e.*, with the habit of a *Zingiber*; mostly small (*H. psittacorum*). Subgenus STENOCHLAMYS Baker.

A. Leaves narrowly oblong, sessile, almost clasping the stem; peduncle short or absent; branch-bracts red, narrow. *H. Choconiana* Wats.

B. Leaves lanceolate or ovate-lanceolate, rounded or subcordate at the base; mostly petioled; peduncle at least as long as the rachis; branch-bracts yellow with red cheeks, broad, often subovate. *H. crassa.*

II. Leaves all borne from nearly the same point on the stem, as in *H. Borinquena* (*f. 3*); mostly very large.

A. Branch-bracts more or less spaced out on the rachis, not overlapping, except at the base (*H. Bihai*). Subgenus PLATYCHLAMYS Baker.

a. Inflorescence pendulous from a long flexible peduncle, glabrous; rachis very flexuose, internodes long, bracts narrow, red; leaves very glaucous beneath. *H. Collinsiana.*

b. Inflorescence erect.

1. Inflorescence long-peduncled.

(*a*) Branch-bracts very close together, narrow, truly distichous, horizontally extended; rachis very straight. *H. librata.*

(*b*) Branch-bracts distant, not strictly distichous; rachis very flexuose.

(1) Inflorescence scarlet, hairy, below the bases of the leaves; leaves green on both sides. *H. tortuosa.*

(2). Inflorescence orange, glabrous, with a very long peduncle which raises it up among the leaves; leaves slightly glaucous below. *H. latispatha* Benth.

2. Inflorescence sessile; rachis straight; branch-bracts narrow, distant, red and yellow, covered all over with short velvety pubescence. *H. spissa.*

3. Inflorescence sessile or very short-peduncled; branch-bracts very broad and close together, often clasping each other at the bases and concealing the stiff, straight rachis.

(*a*) Branch-bracts green with red cheeks; leaves green on both sides when well developed, very long, long-cuneate at the base. *H. elongata.*

(*b*) Branch-bracts bright orange; leaves glaucous below, at least when young, shorter, not cuneate.

(1) Stem upright; leaves turned in all directions, soon green beneath; tips of the branch-bracts acute or bluntish, somewhat incurved and involute; Guatemalan. *H. Champneiana.*

(2) Stem inclined; leaves all spread out horizontally, very glaucous beneath; tips of the branch-bracts long-acuminate, recurved and revolute; Porto Rican. *H. Borinquena.*

B. Branch-bracts very close together on the rachis so as to form a compact flat spike, somewhat resembling the rattle of a rattlesnake (*H. imbricata*). Subgenus TAENIOSTROBUS Kuntze.

Inflorescence pendulous on a long peduncle; plant very large. *H. Mariae* Hook. f.

It will be noticed that in this key the species are arranged in a considerably different way from that used by former writers. Baker and Schumann divide the genus into two subgenera characterized by broad and narrow branch-bracts respectively. Under these subgenera the species are arranged according to an artificial key. This arrangement often separates widely species which are very similar except in some unimportant character, and thus ignores the existence of natural groups smaller than the subgenus. That such groups do exist is certain, *e. g.*, that referred to under *H. Champneiana* and that to which *H. tortuosa* and *H. latispatha* belong. It is believed that their recognition will be of material assistance in the study of the genus. The delimitation of the subgenera has also been considerably emended. It is not to be denied that the shape of the branch-bracts is in a general way correlated with the relationships of the species, but it is only an accidental parallelism without much physiological importance, for there are many exceptions — species quite similar in all respects except that the branch-bracts are sufficiently different to place them in different subgenera as heretofore defined; for instance, *H. tortuosa* and *H. latispatha*. It is an undesirable character to use in a key because of the difficulty of application and the liability to error. In the inflorescences of several species the lower branch-bracts are lanceolate, while the upper are ovate and the intermediate neither one or the other. Besides, there are several species whose branch-bracts are ovate when fresh, but shrink so as to be lanceolate in the herbarium specimen.

Two of the subgenera, *Stenochlamys* and *Taeniostrobus*, are natural groups, but the third, *Platychlamys*, the name of which must of course go with the type, comprises simply the residue. Its present application can be considered only provisional. The extreme form of *Stenochlamys* (*H. psittacorum*) is very different from the members of the other two groups, but the difference is of only subgeneric importance, for these extremes shade through a series of intermediates into the other groups. This is true whatever characters are used to distinguish them, whether the width of the bracts or the habit, but the habit represents a natural difference of some physiological significance; and it seems to me to accord with the probable relationship of the plants.

In the groups with the typical *Heliconia* habit, those species with erect inflorescences have been separated from those whose inflorescences droop. The importance of this character seems not to have been appreciated heretofore because of the lack of field study, and the descriptions of more than one species would have them with indifferently erect or drooping panicles. But it seems very probable that such inferences are the result of identifying two species as one. The ecological relations of the plants in the two cases are quite different. The bracts in the erect inflorescence are always full of water, into which numerous insects fall and decay, and in species like *H. Borinquena* the floral parts themselves are always more or less rotten. The fruit of such species ripens under water; and both flowers and fruit have the full benefit of the sun. But in the pendent inflorescence the flowers are shaded from the sun and rain by the roof-like bract above them, and are subjected to very different conditions. It is a question whether the erect-flowering species are insectivorous or not. If they are not, they would have only to utilize a food supply already present to become so. That this habit is no mere accidental peculiarity of the individual plant will be realized at once by any one who sees in the field how constantly the species adhere to it. With very rare exceptions the erect-flowering species always bear the inflorescence erect, no matter what may be the position of the stem, and vice versa. It is as constant as any character they possess.

Another character which has not received the attention it deserves is color in the inflorescence. The neglect of this is due largely to the method of dealing with dried specimens from which it is absent. My own observation in the field goes to show that it is one of the least variable characteristics of the genus. The shape of the parts, their relative size, and the presence of hair and glaucescence — these are variable and must be used carefully. But in the study of several thousand individuals of the more abundant species no variation in color was detected. The colors of the inflorescence are nearly always bright, but never delicate or such as are usually subject to variations.

HELICONIA CHOCONIANA S. Watson.

Whole plant glabrous, slender, as much as 2 m. tall: leaves reaching a length of 33 cm. and a breadth of 7 cm., oblong, acute or short-acuminate at the apex, cordate and almost clasping the stem, green on both sides: peduncle sometimes as much as 7 cm.

long, rachis flexuose, deflexed; lowest fertile bract 7 cm. long, 2 cm. broad: pedicels 12 mm. long: berries red and yellow, 9 mm. in diameter in the dry specimen.

Our plants (*no. 757*) were larger than Watson's and the peduncle is longer; otherwise they are very similar. They were growing in deep shady forests at Cherujija Oxec, about fifty miles west of the original locality.

Donnell Smith's *no. 8019*, collected by von Türckheim at Cubilquitz, Alta Vera Paz, has a peduncle as long as our plants. From this it would seem that Schumann's distinction (a sessile inflorescence) between *H. aurantiaca* and *H. Choconiana* will not hold. *H. Choconiana* is very close to *H. aurantiaca*, or at least to *H. brevispatha*, which was described as synonymous with it. The peduncles of our specimens are as long as those shown in Hooker's figure and the leaves are similar, but in his species they are broader with short petioles, not clasping. The distinction between the two should be the floral and foliar characters instead of the length of the peduncle.

r45-16

Heliconia crassa sp. nov.

The habit of this plant may be said to be somewhat intermediate between the typical *Stenochlamys* and the rest of the genus. The stem elongates between the nodes so that the leaves are borne along it, as is the case in the former group; but the petioles, instead of diverging at an angle from the stem, continue in nearly the same direction, which is characteristic of the other subgenera. They have at the summit, however, a sharp bend of nearly 90°, so as to bring the blades into the same relation to the stem as is usual in *Stenochlamys*. Such a bend at the summit of the petioles was also seen in several species of the other subgenera (only among those with erect stems); but its amount was small, in no case more than 30°. When growing in shady places this species may attain a height of 2 m., but most of the plants are only about half as tall.

Leaves to 30 cm. long, 9 cm. broad, lanceolate, at the tip acute, at the base oblique or equilateral, rounded or cordate, thick, green, glabrous, and glossy on both sides; principal nerves on the upper surface 5 mm. apart — an unusual distance for so small a leaf; blades sessile or on petioles up to their own length:

inflorescence glabrous; peduncle 5–30 cm. long, pointing in the same direction as the stem, not necessarily upright; panicle about 7 cm. long, of half a dozen horizontally divaricate bracts on a flexuose vertical rachis, orange-yellow shading into orange-red on the cheeks of the bracts; the lowest bract often sterile, ascending and expanded into a greater or lesser blade, the others distant from each other by about their own depth, 3–6 cm. long, about 2 cm. wide, mostly subovate: flowers about 15 to a branch-bract, yellow, as long as the upper bracts: flower-bracts shorter than the flowers, 2–3.5 cm. long, nearly 1 cm. broad: pedicels about 1 cm. long: berries 5 mm. in diameter in the dry specimen.

Heliconia crassa is abundant on the mountains between Sepacuité and Secanquim (on the road from Cahabon to Senaju), but does not cross the divide into Sepacuité. It is oftenest found on the hot hills of the region, which are overgrown with bushes and small trees. It prefers the full glare of the sun. *Nos. 356* and *376* (type).

It is close to *H. subulata* Ruiz & Pavon; it resembles their figure closely, but on examination of the description it is found to differ in several respects. It is only a third as large as *H. subulata* sometimes grows; the leaves of that species reach a meter in length and the inflorescences 30 cm.; the panicle in *H. crassa* is erect, not pendulous; the branch-bracts are much broader, not yellow, tipped with red and not turning red in fruit; and the flowers are fewer to a bract. Its similarity to *H. subulata* suggests possible affinities with the other forms referred to *H. psittacorum* L. as varieties. It has no resemblance to *H. angusta* Vell., which has been considered a synonym of *H. subulata*; beside differences in the inflorescence, that species has leaves more than eight times as long as broad. *Heliconia Andrewsii* Kl., which has been considered another synonym of *H. subulata*, is nearer, but it also has longer leaves; its spathes are narrower, not channelled, and its flowers are very much larger, orange, and *distinctly black-tipped*. From *H. Schomburgkiana* Kl., which, however, is very inadequately described, it differs at least in the broader conduplicate branch-bracts. Eichler's variety, *spathacea*, which has been considered identical with it, has, as shown by Petersen's figure, long narrow leaves almost like the species. Petersen's variety, *gracilis*, has not been taken up by recent writers because of insufficient description; the branch-bracts are broad like those of *H. crassa*, but no mention is made of the leaves, which would, therefore, be expected to be like those of *H. psittacorum* and very much narrower than those of the present species.

170 **Heliconia Collinsiana** sp. nov.

The few plants of this species we saw were growing in a clump at the top of a steep bank by the roadside. They were lopping over upon the surrounding shrubbery as though unable to stand alone; the leaves were spread out to catch the sun like those of *H. Borinquena* (*f. 3*).

Whole plant about 5 m. long: leaf-bases 2.75 m., petiole 1 m., blade 1.25 m.; blade oblong, gradually narrowed to the tip, obliquely cordate at the base, decidedly inequilateral in the type, the sides being 17 and 22 cm. respectively, bright green above, below very glaucous, with a little fine fuzzy pubescence on the midrib, otherwise glabrous: inflorescence bright red, glabrous, 45 cm. long, pendent on a slender peduncle 30 cm. long; branch-bracts lanceolate, the lowest linear-lanceolate, gradually narrowed to a blunt tip, very distant on the very flexible but slightly flexuose rachis, lowest 30 cm. long, 4 cm. broad, those half way up 15 cm. long and 3 cm. broad: flowers and their bracts not seen; few flowers (less than a dozen) to a branch-bract: pedicels 15–25 mm. long: berries 15 mm. in diameter when fresh.

On the bank of the Cahabon river about five miles below the ford by which the road crosses to the town of Cahabon (*no. 352*). It gives me great pleasure to name this species after my friend and associate, Mr. G. N. Collins; but for his pointing it out to me I would have ridden by without seeing it.

Donnell Smith's *no. 2102* from Masagua, Escuintla, is probably the same species. The leaf with his specimen is only 52 cm. long, 25 cm. wide, ovate and green below; its slender petiole, however, shows that it is not one of the large leaves of the plant, but from one of the small lateral suckers whose leaves are always shorter than those of the main stem. The same fact may also explain the absence of glaucescence, but the whole group is very variable in that respect. The inflorescence of this specimen resembles that of the type closely, but the branch-bracts are somewhat broader and each has more flowers.

According to the artificial key given by Schumann *Heliconia Collinsiana* could belong only with *H. pulverulenta* or *H. glauca*, but it is very different from both. *H. glauca* has a red rachis, pedicels and fruit, combined with green bracts and flowers. *H. pulverulenta* belongs to *Stenochlamys*; its peduncle is not drooping, the inflorescence is much smaller with fewer bracts, the rachis straighter and the bracts closer. The relationships of the present species are more probably with *H. pendula*. Donnell Smith's *no. 4635*, which was doubtfully labelled as that species by Baker, is closely related to the present plant but has a very hairy inflorescence and differs in other characters. It seems, however, to differ from *H. pendula* also. The present species differs obviously from the latter in the glabrous inflorescence and the longer branch-bracts.

22 **Heliconia librata** sp. nov.

At the time of our visit this species had passed its season and, though many plants were observed, none were seen with fresh flowers; the inflorescences of all were dead and dry like the type, which was in the same condition when collected as now. The habit of the plant is like that of *H. latispatha*, which the present plant resembles much in all respects except the inflorescence. It is erect in all its parts.

About 3 m. tall: stem 75 cm. long: petioles 90 cm. long; blade 115 cm. x 25 cm., oblong-elliptical, rounded and abruptly short-acuminate at the base, acute or slightly acuminate at the tip, glabrous, glaucous below: inflorescence on a very long (75 cm.) erect peduncle, green according to the statement of the Indians, triangular in outline, almost as broad as long, composed of 12–16 bracts about a centimeter apart, most of them extended at right angles to the straight rachis; type inflorescence glabrous except for a few hairs on the rachis; branch-bracts (except the upper) lanceolate, the lowest sterile, 20 cm. long, 4 cm. broad, with a small lamina at its tip; largest of the fertile bracts about half as long but of the same width, the topmost only 3 cm. long: pedicels 10–15 cm. long.

Heliconia librata is a lowland form, abundant in the upper part of the Oxec valley, but does not occur in any other region we visited (*no. 696*, Cherujija Oxec).

According to the artificial keys it belongs in Baker's section *Stenochlamys* and would be nearest to *H. glauca*, which it scarcely resembles even in general appearance and differs from sufficiently, as far as characters go, in having the leaves more than twice as large, the internodes of the rachis shorter and the bracts more numerous. The relatively short rachis and the long peduncle, with the comparatively large number of branch-bracts, suggest that this plant is near those species with a head of densely imbricated bracts for which the section *Taeniostrobus* was erected.

40 **Heliconia tortuosa** sp. nov.

Whole plant about 3.5 meters in height (trunk 1.75 m., petioles 75 cm.): leaves about a meter long, 20–30 cm. broad, rounded and oblique at the base, abruptly short-acuminate at the tip, bright green and glabrous on both sides except that the midrib, below, and the petiole bear more or less coarse matted brown hair: inflorescence brilliant scarlet, erect or nearly so; peduncle long, stiff, aligned with the stem; lowest bract often developing a large blade, sometimes nearly as large as the other leaves; rachis extremely flexuose; the few bracts (about half a dozen) distant from each other by about their own depth, not truly distichous but arranged in a sort of spiral with an angle of about 120° between them, lowest about 12.5 cm. long, 5 cm. broad; the upper nearly as large, subovate, triangular, straight-sided, not tapering, with a blunt frayed point; rachis between the upper bracts attaining its full extension almost as soon as they separate from the head formed by those above them which have not yet opened out; bases of bracts at least, and rachis covered with matted brown wool: flowers green, 5–7 cm. long, projecting above the edges of the branch-bracts; flower-bracts two thirds as long as the flowers; floral parts glabrous except for an occasional hair. (Pl. 29, f. 1.)

✓*No. 17*; photographs *3610* and *4130*. *Heliconia tortuosa* is the only representative of the genus common about Sepacuité, but in the valley which the plantation occupies it is one of the most conspicuous plants; it grows everywhere except in the thickest woods where the light is too weak. Donnell Smith, *no. 1828*, Pansamalá, Alta Vera Paz, alt. 3800 feet, April, 1899. The bracts are longer and narrower than in our specimen.

Heliconia tortuosa is very similar to *H. villosa* Kl., from Colombia, or at least to the printed descriptions of it. The similarity is due, I suspect, more to lack of detail in the descriptions than to resemblance in the plants. Petersen's plate in the "Flora Brasiliensis" shows a very different plant from the present and emphasizes the discrepancies between the two. The Guatemalan species differs from the Colombian in having (1) a peduncle straight and stiff, not curved; (2) an oblong, not a deltoid, panicle; (3) a very flexuose rachis; (4) bracts not approximated and fewer than in *H. villosa*; (5) flower-bracts glabrous, shorter than the flowers, not hirsute and of the same length; (6) flowers larger, glabrous, not hairy, pedicelled, not sessile, ovary glabrous, not pubescent; (7) leaves obliquely rounded at the base and short-acuminate at the tip, not subattenuate, alike at both ends.

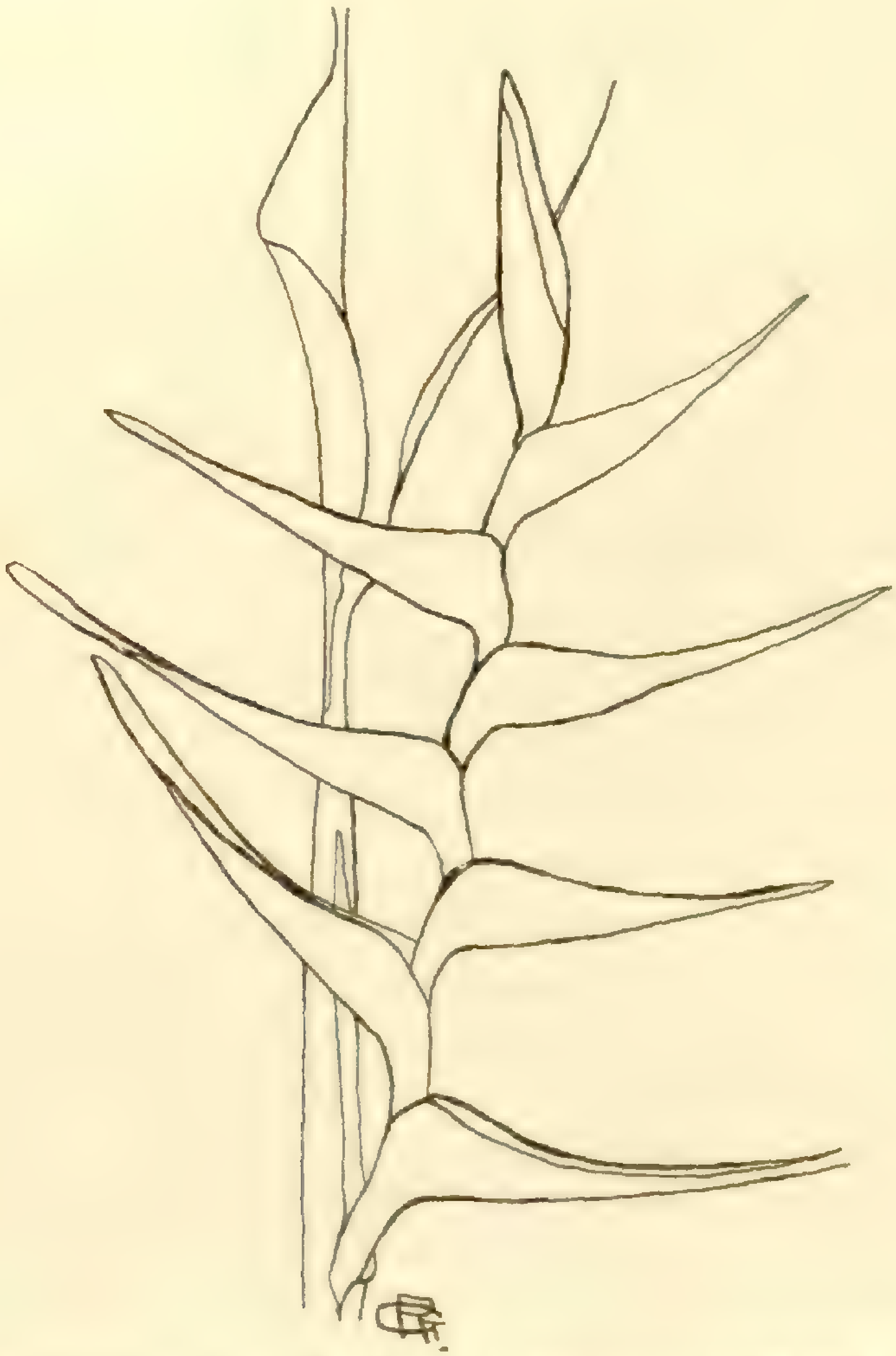

FIG. 1. *Heliconia latispatha* Bentham. Inflorescence just before anthesis. Note that though the branch-bracts are quite narrow, the flowers are not visible. Traced from a photograph by Mr. G. N. Collins (*no. 129*).

HELICONIA LATISPATHA Bentham

Whole plant about 2.5 m. tall; stem 15 cm. in circumference, green at the base but above and on the petioles covered with a thin evanescent bloom: petioles about 50 cm. long: leaf-blades 1 m. by 30 cm., short-acuminate at the tip, obliquely narrowed to the base, glabrous on both sides except for the midrib which is somewhat hairy, slightly glaucous below: inflorescence borne at the summit of a long (60 cm.) peduncle; lowest bract, which is sterile, and sometimes the next, expanded into leaves which may attain a large size; branch-bracts 8–10, rich orange, rachis greenish-orange; bracts narrowly lanceolate; one from the middle is 15 cm. long, 3–4 cm. broad (dry): flowers very small, entirely hidden below the edges of the bracts, 30–35 mm. long, subtended by triangular-ovate bracts of about the same length and 12–15 mm. broad, pedicels apparently not pubescent as they are described in *H. latispatha* and there is no hair on any part of the inflorescence. (FIG. 1.)

Secanquim, about half way between Senaju and Cahabon (*no. 262*, photographs *128*, *129*). It is very abundant on the hillsides around Secanquim, where it occupies the same place in the plant societies as does *H. tortuosa* higher up about Sepacuité.

Donnell Smith, *no. 1829*, Rio Dulce, Dept. Livingston. In this specimen, which is more mature than ours, even good sized fruits are very short-pedicelled and barely look over the edges of the narrow branch-bracts.

The panicle is oblong in outline like that of *H. tortuosa*, to which the present plant is closely related. As in that species the branch-bracts are not truly distichous, but are only approximately opposite and the rachis is strongly flexuose. But the peduncle is much longer, so that the inflorescence though originating at about the same part of the plant is much higher up; instead of being half way down the stem it is about level with the bases of the leaves.

216 **Heliconia spissa** sp. nov.

Plant about 2 m. long, with a habit like *H. Borinquena* (*f. 3*), leaning over with its leaves all horizontal: blade 75 cm. long, 20 cm. wide, oblong-oval, acute at the tip, rounded to the base, green and glabrous except for the under side of the midrib which bears more or less coarse brown hair; main nerves only 3 mm. apart — whence the name: inflorescence practically sessile (on a peduncle only 25 mm. long), stiffly erect, thickly covered with soft short brown hair except on the edges and channels of the bracts, rachis straight, hardly flexuose; branch-bracts distant from each other by more than their own depth except near the tip of the panicle, oblong-lanceolate, acute or obtuse, the lowest 17 cm. long, 1.5 cm. broad; lowest fertile bract 8 cm. long, 1.5 cm.

broad, uppermost 4 cm.; whole inflorescence bright yellow, shading to orange on the cheeks of the branch-bracts: flowers a dozen or less to the bract, about 4 cm. long, yellow, densely covered with the same soft short hair as the rest of the inflorescence, not scabrous; flower-bracts 25 mm. long, nearly 10 mm. broad, triangular acute, densely pubescent, especially on the midrib; pedicels 1 cm. long, hairy: berries (not ripe) also hairy.

Along the road from Cahabon to Senaju (*no. 359*) growing on a steep river bank a mile further east than *H. Collinsiana.* It is known to me from a single clump with only one inflorescence.

Heliconia spissa very nearly corresponds with the descriptions of *H. Schiedeana.* But they are lacking in detail except as to floral characters. The most obvious difference is in the color of the branch-bracts, which is red in that species but yellow and orange in the present.

Heliconia elongata sp. nov.

Plant generally erect in all its parts, 2–4 m. tall (type, 3.5 m. with a stem 1.5 m., petiole 0.5 m., blade 1.5 m.), glabrous: leaf elongated-oblong, only one seventh as broad (22 cm.) as long, very long-cuneate at the base, rounded to the suddenly short-acuminate tip, green on both sides; mid-rib very large and stiff, 15 mm. in diameter near the base of the leaf: inflorescence upright, without a peduncle, oblong in outline, composed of a dozen or more deeply boat-shaped bracts with clasping bases which hide the stiff, straight rachis; branch-bracts green on the edges and bottom, shading through yellowish-green to a small patch of weak, light red on the cheeks but nowhere crimson; one from the middle of the spike 13 cm. by 9 cm. (measured dry), all ovate, gradually tapering to the sharply acuminate tip: flowers 8 cm. long, bright green at the exposed tips, just projecting above the edges of the branch-bracts; segments of the perianth linear oblong; flower-bracts 5 cm. long, 2 cm. broad, triangular-ovate. (FIG. 2.)

No. 790. It grows all along the Polochic River and up into the hills to an altitude of about 2,000 feet along the road from Panzos to Sepacuité, where a few clumps of it were seen growing with *H. Champneiana.* It covers a greater area and thrives under more varied conditions than any other species studied.

Donnell Smith, *no. 1830*, "Monte Cachirulo, Depart. Yzabal, alt. 700 pp. April, 1899."

Heliconia elongata is closest to *H. humilis* but differs in stature, in the shape of the leaves and in having nearly twice as many branch-bracts, which are not nearly as highly colored, those of *H. humilis* being deep scarlet with only a narrow margin of green near the tip. It also resembles *H. rutila* (see below), but differs in the narrow perianth-segment, the wider more numerous *green* and red branch-bracts and the shape of the leaves.

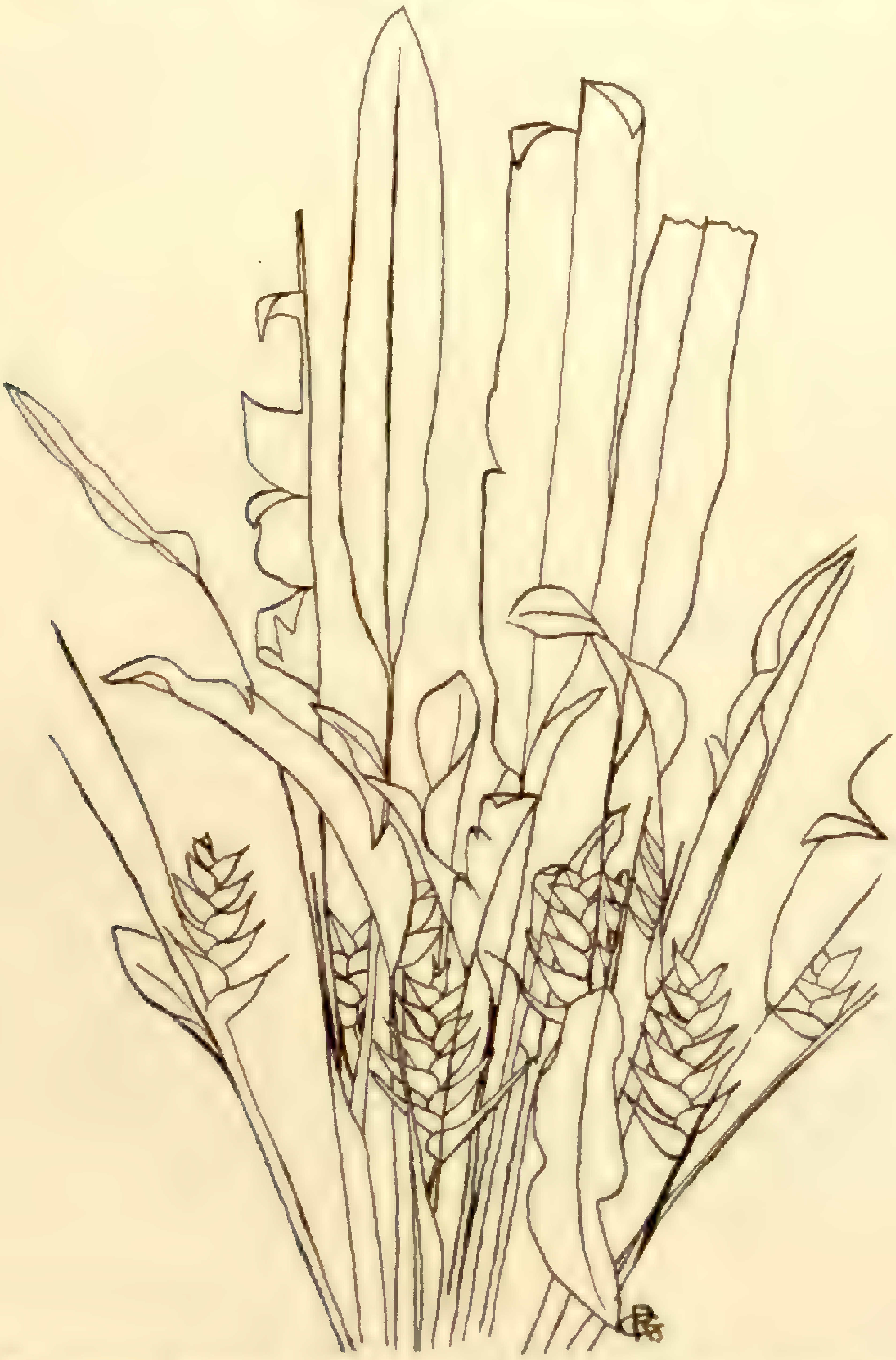

FIG. 2. *Heliconia elongata* sp. nov. The type clump, showing how conspicuously erect are the inflorescences, regardless of the stem angle. Traced from a photograph.

In studying *Heliconia elongata*, it has been necessary to determine *H. Bihai.* That species is the type of the genus and for a long time was the only one recognized. As is not unusual in monotypic genera, to the one species were referred all the Heliconias discovered for a long time. In this way *H. Bihai* became a "composite" to which different authors referred very different plants, and consequently has been a source of much difficulty and confusion. This confusion has continued to the present time, and the recent monographers have not cleared it away but have made their descriptions so general as to include most, though not all, of the various plants described in the places they cite. To determine what *H. Bihai* really is and to limit the name to a single species is not an easy task, but it is necessary for any precision in dealing with it and the related species. In attempting to make such a determination we are aware of the great possibility of error, but we consider it less serious to commit a nomenclatorial blunder by applying the name to the wrong plant than to make the taxonomic mistake of referring several species to one. Besides it is more likely that any nomenclatorial uncertainty will be removed, if it can be, after the species themselves are differentiated.

For some reason Linnaeus in what is, for nomenclatorial purposes, the original description * in the "Species Plantarum," cited Plumier's last species (*variegata*) first. Were this determinable it would be the type of *H. Bihai*, but beyond the reference to the variegated branch-bracts we know nothing about it and there seems to be no way of finding out anything else. Therefore we reject this species from consideration and take up the next cited, one with scarlet bracts, which was Plumier's first species. The early French writers that had access to Plumier's manuscripts are united in considering that this was the species figured by Plumier and in calling it *Heliconia Bihai.* Their figures and descriptions are in substantial accord with his but add a great deal to them. Burmann, in 1756, published a plate from Plumier's manuscripts showing the whole plant and the floral parts full size. The drawings of the flowers are almost identical with those published earlier by Plumier himself, and almost certainly came from the same species. Plumier, in the earlier work, gave no hint as to which of the three species he was figuring, but the identity of his figures and Burmann's show that both were drawn from the species with scarlet branch-bracts which alone was referred to by Burmann. This *Heliconia Bihai* may be briefly described as follows:

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* "MUSA spadice erecto. *Bihai.*
Bihai amplissimis foliis, florum vasculis variegatis. *Plum. gen.* 50.
Bihai. *Ovid. l.* 8, *c.* 9. [Should be lib. 7. cap. 9. — R. F. G.]
β. Bihai amplissimis foliis, florum vasculis coccineis. *Plum. gen.* 50.
γ. Bihai amplissimis foliis, florum vasculis subnigris. *Plum. gen.* 50.
Habitat in America *calidiore.*"—L. Sp. Pl. 1043. 1753.

HELICONIA BIHAI L.

Bihai florum vasculis coccineis Plum. N. Pl. Am. Gen. 50. *pl. 3.* 1703.

Musa Bihai L. Sp. Pl. 1043. 1753 (in part).

Bihai Plum. Pl. Am. ed. Burm. 49. *pl. 59.* 1756.

Heliconia Bihai L. Mant. Pl. 211. 1767 (in part). Jacq. Pl. Rar. Hort. Schoen. **1**: 26. 1797. Lam. Encyc. *pl. 148.* 1823. L. C. Richard, Nova Acta, **15**, suppl.: 22. *pl. 8, 10.* 1831.

Whole plant 3–4 m. tall, erect, glabrous: leaves subdistichous, nearly 2 m. long, 50 cm. broad, round at both ends, long-petioled: inflorescence stiffly erect; peduncle thick, as long or longer than the straight rachis, raising the inflorescence up among the leaves; branch-bracts scarlet, broadly ovate, acuminate, mostly concealing the rachis: perianth-segments narrow, oblong linear; flower-bracts ovate, acute.

The habitat of this plant is uncertain, but it probably came either from one of the French West Indies, most likely Martinique, or from Guiana.

This clears the way for the consideration of the other plants confused with *H. Bihai.* The first was described by Swartz (Obs. Bot. 96. 1791). The description is mostly of flowers and is hardly definite enough for specific determination. Its bracts, however, are different in color from those of *H. Bihai* and on that account it was renamed *H. luteofusca* by Jacquin.

In Andrews's Repository (*pl. 640*) is figured as *H. Bihai* a species with a sessile inflorescence whose bracts are purple with bright yellow edges. In general appearance it is similar to *H. humilis,* though taller. For this the name **Heliconia purpurea** is suggested.

Another so-called *Heliconia Bihai* was figured by Loddiges (Bot. Cab. *pl. 252*) and by Edwards (Bot. Reg. *pl. 374*). The plant is about 3 meters high, with few leaves and erect habit like *H. elongata.* Inflorescence sessile, upright; rachis red (visible), but little flexuose; bracts narrow, ovate-lanceolate, hardly touching each other, red with yellow margins; flower broad and short, perianth-segments broad, flower-bracts ovate. It differs from *H. Bihai* in the habit, in the acute leaf and in the sessile inflorescence; and from *H. purpurea* in the color and width of the bracts. For this plant the name **Heliconia rutila** is suggested. 2.0

A fourth species is described by Petersen in the Flora Brasiliensis (**3**^{3}: 16. *pl. 5*). This, Petersen himself believed to be different from Richard's species, but he supposed it to be the same as Swartz's, to whom he credits the name. It differs from *H. Bihai* in having acuminate glaucous leaves; a long, weak, flexible peduncle, a very flexuose rachis with internodes 3–5 cm. long; distant, narrow, branch-bracts; and triangular flower bracts. For this species the name **Heliconia distans** is proposed. As the Flora Brasiliensis is not accessible to everyone, it may be of interest to add that a reduction of Petersen's plate of *H. distans* is given in Schimper's Pflanzen-geographie, page 359. 175

For a summary, a key to the species confounded with *Heliconia Bihai* may be given:

Peduncle long, stiff, erect; branch-bracts red, broad, close together; leaves round at both ends, green on both sides. *H. Bihai.*
Peduncle long, flexible, curved; branch-bracts red and yellow, narrow, distant; leaves acuminate, glaucous below. *H. distans.*
Peduncle none, leaves green on both sides, acute.
    Branch-bracts red and yellow, narrow, barely touching each other; perianth-segments short and broad. *H. rutila.*
    Branch-bracts purple and yellow, broadly ovate, close together; perianth-segments linear. *H. purpurea.*

173 **Heliconia Champneiana** sp. nov.

Whole plant 5.5 m. tall (stem 1.5 m., petiole 1.5 m., blade 2 m.), erect: stems, petioles and blades of the leaves upright and turned in all directions, *i. e.*, tangential to circles centering in the stem: stem beset with long, straight light brown hairs projecting at right angles: leaves 2 m. long, about 50 cm. wide, tip rounded, not acute, base obliquely cordate; covered when young with a slight bloom on the under surface, which disappears with age and in drying, leaving them green and glabrous on both sides: inflorescence about 45 cm. long, oblong in outline, composed of about 9 bracts, bright orange with occasional red splashes: peduncle short and stout, not more that 25 cm. long, hairy; branch-bracts close together, hiding the rachis and touching the base of the next above them, on the other side; upper nearly uniform in shape and size, about 14 x 11 cm. (measured dry), broadly ovate, deeply boat-shaped, slightly tapering to a blunt somewhat incurved tip; rachis straight, glabrous like the bracts; each bract very many-flowered: flowers about 7.5 cm. long, green outside, white inside, pubescent in two broad lines up the back, otherwise glabrous; flower-bracts glabrous, nearly as long as the flowers, quite broad. (PL. 30.)

No. 528; photographs *4, 5. Heliconia Champneiana* was first seen on the steep mountain side up which zigzags Mr. Champney's road from Panzos to Sepacuité. Later it was observed east of Cahabon in the valley of the Oxec river. It gives me much pleasure to associate with this species the name of Mr. Kensett Champney, whose great and precise knowledge of the flora, fauna, customs and language of the country makes him an authority on all that pertains to the natural history and anthropology of Alta Vera Paz. To him we are indebted for a great deal of valuable information and for all the courtesies which he and Mr. and Mrs. Owen united to show us during our visit to Sepacuité.

Heliconia Champneiana may be taken as the type of a very compact and natural section of the genus including *H. rutila, H. purpurea*, *H. elongata* and *H. Borinquena.* These are all characterized by practically sessile, erect inflorescences, stiff straight rachises and by relatively broad often clasping branch-bracts.

Heliconia Borinquena sp. nov.

This species is very similar to the Guatemalan plant just described, but is somewhat smaller in all its parts. Whole plant 3–4 m. long with 3–5 leaves on petioles about 1 m. long and sheathing bases twice as long. Its habit is different from *H. Champneiana;* instead of growing erect it leans over and spreads out all its leaves horizontally. (FIG. 3.)

Leaves 1–1.25 m. long, about 30 cm. broad, rounded at the base, acute or short-acuminate at the tip, glabrous, green above, decidedly glaucous beneath: inflorescence conspicuously upright no matter what may be the position of the stem, glabrous throughout, oblong, about 30 cm. long, half as wide; branch-bracts 8–10, very broadly ovate, broader than in *H. Champneiana*, all except the lower nearly as broad as long (one from the middle of the spike measures 12 cm. both in breadth and length), closely clasping and overlapping each other at the bases so that the side of one is on a level with the bottom of the next above it, on the same side of the rachis, much closer than in *H. Champneiana*; their tips long, subulate, recurved with revolute margins; flowers greenish, about 11 cm. long, tips projecting above the edges of the branch-bracts; flower-bracts about 9 cm. long. (PL. 29, F. 2.)

Growing on the steep sides of a wet clay ravine amid a tangle of tropical underbush, near the military road, 13 km. north of Cayey, Porto Rico (Underwood and Griggs *no. 363*, June 24, 1901; photographs *2827* and *2829*.)

Our specimens of *H. Borinquena* are, with one exception, the only representatives of the genus in the National Herbarium from Porto Rico. The exception is Sintenis's *no. 1131* from near Bayamon, which was determined as *H. Bihai.* Since, however, that species has leaves green on the under side such a reference is probably a mistake, for the leaves of Sintenis's specimen are very glaucous below. Its leaves suggest *H. Borinquena*, for they are of about the same texture and size — as far as one can tell from the fragments preserved — but it has a long slender peduncle and the bracts are longer, narrower and triangular-ovate, without the subulate recurved tip (in the specimen).

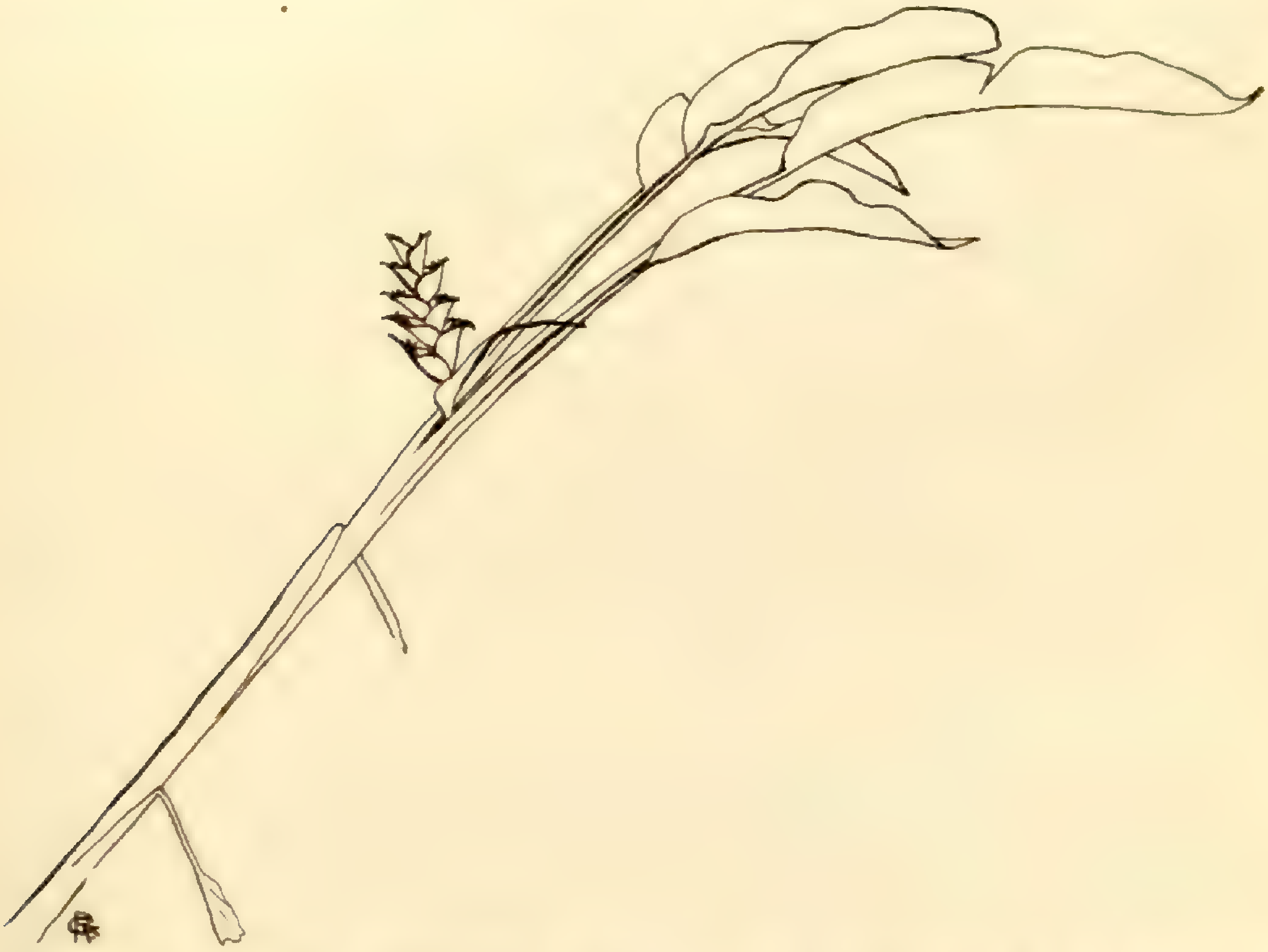

FIG. 3. *Heliconia Borinquena* sp. nov. Whole plant, showing the habit and the upright inflorescence. Traced from a photograph by Mr. G. N. Collins (*no. 2827*).

Heliconia Borinquena and *H. Champneiana*, which is closely related to it, are easily distinguishable from the others of the group to which they belong by the orange branch-bracts, for all the others are margined with a color different from that of the cheeks.

HELICONIA MARIAE Hook. f.

This species is a giant in a genus of giants; it sometimes reaches a height of 12 meters when growing in the shade and protected from the weather. Most plants are, however, not more than two thirds as large. Its general appearance when growing in masses is strikingly similar to that of a banana plantation, though the individual plant would never, even if not in flower, be mistaken for a banana, because of the smaller number of leaves.

Leaves 2–3 m. long, about 60 cm. broad, oblong-elliptical, obliquely subcordate at the base, acute at the tip, when young covered with a slight evanescent bloom: inflorescence a dark rose-color, at the end of a long (60 cm.) nodding peduncle; bracts densely imbricated, concealing the rachis in the fresh specimen, panicle generally not much longer than broad, but sometimes very long, with very many branch-bracts; lowest fertile branch-bracts slightly reflexed, ovate, 8–9 cm. long, 7–8 cm. broad, attenuate to a blunt frayed tip, narrowed to the base, those from the middle of the inflorescence nearly orbicular when spread out, 6–7 cm. long, 7–8 cm. broad, widest at the middle, narrowed both ways to the blunt tip and base, with more or less short soft brown hair: flowers about ten to a branch-bract, their exposed tips rose, fading into white on the shielded portions, 4–5 cm. long, with flower-bracts a little shorter and sometimes at least 2 cm. broad, often conduplicate and keeled below where compressed by the surrounding flowers, part of them hairy; ovary white, turning deep blue when ripe; pedicel very variable in length.

There are some discrepancies between this plant and the descriptions of Hooker's plant, but they are mostly in size and hairiness. In more constant particulars they seem to correspond very well.

This species grows abundantly around and a little above Panzos (*no. 787*). None of it was seen along the Polochic, nor does it ascend to Sepacuité. A solitary clump was seen in the valley of the Oxec.

Beside the species already described one other was collected in the valley of the Oxec. Only one plant was seen and that toward night when we were hurrying to reach our destination, and a part of this specimen was lost, so that it is better to pass it till another time when fuller material can be had. It was of the subgenus *Stenochlamys*, perhaps closest to *H. cannoidea* Rich., 1.5 m. tall, with seven leaves, 40 cm. long, not quite 10 cm. broad, sessile with long acute bases, acuminate at the tip; green and glabrous on both sides; peduncle a little less than 10 cm. long; inflorescence bright scarlet, about the same shade as in *H. tortuosa*, rachis deflexed, flexuose, lowest bract 17 cm. long with a small blade at the end, next 9 cm., both about 2 cm. broad (*no. 693*).

Explanation of Plates

PLATE 29

FIG. 1. *Heliconia tortuosa* sp. nov. The inflorescence, one half natural size. Photographed in the field by Mr. G. N. Collins (*no. 3610*).

FIG. 2. *Heliconia Borinquena* sp. nov. The inflorescence, one half natural size. Photographed by Mr. G. N. Collins (*no. 2829*).

PLATE 30

Heliconia Champneiana sp. nov. A portion of the type in situ showing the upright habit. (Photograph *no. 5.*)

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Andrews, H. Bot. Rep. 2: *pl. 124*. 1800; 10: *pl. 640*. 1812. Gives good colored plates from garden specimens of *H. psittacorum* Sw. (not L. f.) (*H. Andrewsii* Kl.) and *H. Bihai* (*H. purpurea*), with descriptions of each.

Aublet, F. Hist. Pl. Guiane Fr. 2: 931. 1775. Describes *Musa Bihai* and *M. humilis*.

Baker, J. G. A Synopsis of the Genera and Species of Museae. Ann. Bot. 7: 189–222. 1893. Describes *H. platystachys* and *H. Burchellii*.

Bentham, G. Bot. Sulphur, 170, 171. 1844. The original descriptions of *H. latispatha* and *H. vaginalis*; they are brief, unillustrated, and drawn mostly from variable floral characters so that they are very unsatisfactory.

Browne, P. Civ. and Nat. Hist. Jam. 364. 1756. Describes in a general way, as a *Musa*, a Jamaican *Heliconia*, but does not give sufficient material for specific reference.

Chamisso, A. von & Schlechtendahl, D. F. L. von. Linnaea, 6: 57, 58. 1831. A brief collector's note but hardly a description of the plant afterward named *H. Schiedeana*.

Edwards, S. Bot. Reg. 5: *pl. 374*. 1819. Gives a good colored plate of *H. Bihai* (*H. rutila*).

Ender, E. Gartenfl. **20**: 152. 1871. A notice of *H. vinosa*, with a brief description of it.

Guilmot, G. Fl. Serr. Jard. **23**: 125. *pl. 2416–17.* 1880. Figures and describes *H.? striata*. It is without flower, and is more likely than not a member of some other genus.

Hooker, J. D. On a new *Heliconia* with the habits of a *Musa*, sent from New Granada. Jour. Linn. Soc. London, **7**: 68, 69. 1863. Gives a full and complete description of *H. Mariae*, but no figure.

——— *Heliconia humilis* Jacq. Curt. Bot. Mag. III. **22**: *pl. 5613.* 1866. A good description, with a colored figure, of Jacquin's species.

Hooker, W. J. *Heliconia Brasiliensis.* Hook. Exot. Fl. **3**: *pl. 190.* 1827. Original description, full, with a good colored plate.

——— *Heliconia angustifolia.* Curt. Bot. Mag. III. **5**: *pl. 4475.* 1849. A good description, with a colored plate.

——— *Heliconia pulverulenta.* Curt. Bot. Mag. III. **7**: *pl. 4685.* 1852. Description with colored figure.

——— *Heliconia metallica.* Curt. Bot. Mag. III. **18**: *pl. 5315.* 1862. Original description, with colored figure.

——— *Heliconia brevispatha.* Curt. Bot. Mag. III. **19**: *pl. 5416.* 1863. Described as a synonym of *H. aurantiaca* Ghiesb.; a full description illustrated with a good figure.

Jacquin, N. J. Pl. Rar. Hort. Schoenb. **1**: 23. *pl. 48, 49.* 1797. Here is described *H. humilis* with two large, carefully drawn colored plates. Jacquin is the only one of the early writers that had opportunity to study the plants in the field, and consequently his descriptions are better and his conception of the relationships, number and distinctness of the species are clearer than those of his contemporaries.

Klotzsch, J. F. Beiträge zu einer Flora der Aequinoctial-Gegenden der neuen Welt: Musaceae. Linnaea, **20**: 462–466. 1847. Describes as new species *H. Meridensis, H. villosa, H. Schiedeana, H. Schomburgkiana* and *H. bicolor*, briefly and without figures.

——— in Schomburgk Reisen Brit.-Guiana, **3**: 815, 919, 1070, 1125, 1126. 1848. Lists, with notes of flowering, the following: *H. acuminata, H. Ballia, H. bicolor, H. Bihai, H. flexuosa, H. pulverulenta, H. Richardiana* and *H. Schomburgkiana.*

Kuntze, Otto. Rev. Gen. Pl. **2**: 684. 1891. Description of *Bihaia imbricata* and of section *Taeniostrobus*, with a list of the species, which are transferred to Kuntze's genus *Bihaia.*

Lamarck, J. B. A. P. M. Encycl. **1**: 426. 1783; *pl. 148.* 1823. Describes all the Heliconias known at that time, as he understood them, and figures *H. Bihai.*

Lindley, J. Bot. Reg. **19**: *pl. 1648.* 1834. Original description of *H. pulverulenta*, with colored figure.

Linnaeus, C. Sp. Pl. 1043. 1753; ed. 2. 1477. 1763. First binominal reference to a *Heliconia* under the name *Musa Bihai.*

——— Mant. Pl. 211. 1771. The original application of the generic name.

——— Syst. ed. 13. 204. 1774. The first description of the genus.

——— (filius) Suppl. Syst. Veg. 157–159. 1781. Describes *H. alba*, *H. psittacorum*, *H. hirsuta.*

Loddiges, C. Bot. Cab. 3: *pl. 252.* 1818. Gives a colored habit-figure of *H. Bihai* (*H. rutila*).

Merian, M. S. de. Hist. Gén. Insect. Surinam. 1: 54. *pl. 54.* 1771. Gives a description with a plate of a *Heliconia* called "Ballia" by the Indians.

Miller, P. Gard. Dict. 1739. A popular and indefinite description of "*Bihai.*"

Oviedo, G. F. de. Hist. Gen. y Nat. Indias. lib. 7: cap. 9. Gives an account of a plant called "Bihas" and its uses.

Paxton, J. *Heliconia Brasiliensis.* Paxt. Mag. Bot. 3: 193. 1837. Gives a good colored figure and a habit-figure, in addition to a full description.

Petersen, O. G. Musaceae, in Mart. Fl. Bras. (fasc. 107) 3^3: 1–27. *pl. 1–8.* 1890. Describes 25 species, the new ones being *H. elegans*, *H. conferta*, *H. Wagneriana*, *H. Bourgaeana* and *H. curtispatha.*

——— Musaceae, in Engler & Prantl, Pflanzenfamilien, 2^6: 1–10. 1889.

Plumier, C. Nov. Pl. Am. Gen. 50. *pl. 3.* 1703. Describes three species of *Bihai* and figures the flower of one.

——— Pl. Am. ed. Burm. 49. *pl. 59.* 1756. A better figure and description of Plumier's plant.

Poeppig, E. Reise in Chile, Peru und auf dem Amazonstrome, 2: 295. 1836. The original application of *H. velligera*, without much description.

Regel, E. Gartenfl. 16: 90, 245. 1867. A review of the original description of *H. pendula.*—Notice of *H. humilis* Jacq.

Richard, L. C. Mus. Comm. Bot., Nova Acta. 15: suppl. 1831. A very important paper illustrated with twelve plates in which *H. Bihai*, *H. acuminata*, and *H. cannoidea* are figured.

Rodigas, E. Ill. Hort. 29: 59. *pl. 448*; 29: 155. *pl. 464.* 1882. Figures and describes *H? triumphans* and *H? aureostriata.* Both these are foliage plants without flowers, and are as likely Cannas as Heliconias, which they do not particularly resemble in habit.

Ruiz, H. & Pavon, J. Fl. Per. & Chil. 3: 70, 71. *pl. 303–305.* 1802. Describe and figure *H. subulata*, *H. lingulata* and *H. rostrata.*

Rumphius, G. E. Herb. Amboin. 5: 142. *pl. 62. f. 2.* (1695). 1747. A reference to a Musaceous plant, supposed to be a *Heliconia*, found wild in Amboyna.

Schimper, A. F. W. Pflanzen-geographie. Jena, 1898. On page 359 is given a reduced reproduction of Petersen's figure of *H. Bihai* (*H. distans*).

Schumann, K. Musaceae, in Engler's Pflanzenreich (Heft 1), 4^{15}: 1. 1900.

Sims, J. *Heliconia psittacorum* Sw. Curt. Bot. Mag. **14**: *pl. 502.* 1801. Colored plate and description of *H. Andrewsii.*

Swartz, O. Obs. Bot. 96. *pl. 5. f. 2.* 1791. Describes *H. Bihai* Sw. and *H. psittacorum* Sw. (*H. Andrewsii* Kl.), and figures the former.

Vellozo, J. M. Fl. Flumin. **3**: *pl. 19–22.* 1827. Text (Archiv. Mus. Nac. Rio Jan.), 29. 1881. Figures and describes *H. Biahij*, *H. angusta*, *H. thalia*, *H. episcopalis.*

Verlot, B. *Heliconia glauca.* Rev. Hort. **40**: 112. 1869. *Heliconia densiflora*, *l. c.* 274. Very good descriptions accompanied by colored plates.

Watson, Sereno. Proc. Am. Acad. **23**: 284. 1888. Describes *H. Choconiana.*

——— Gard. and For. **1**: 161, *f. 31.* 1888. Repeats the description, and gives a figure of the plant.

A Summary of our Present Knowledge of the Ferns of the Philippines

By Lucien Marcus Underwood

Linnaeus included a single fern from the Philippines in the first edition of his *Species Plantarum*. This was called *Adiantum Philippense* and was based on a figure of Petiver, who seems to be the sole authority for the source of the fern. Hooker referred the plant with some hesitation to *A. caudatum*, which appears to be a common species in the islands. The early European travelers collected a few ferns in the Philippines, some of which were described by Cavanilles early in the last century; the types of these species are presumably at Madrid. Chamisso included the Philippines in his travels and Kaulfuss described several Philippine ferns in his *Enumeratio* (1824). Presl described a number collected by Thaddeus Haenke and by Née in his *Reliquiae Haenkeanae* (1830) and others still from the same collectors in *Epimeliae Botanicae* (1849). Gaudichaud also visited Luzon and collected a few species. It was not, however, until 1836–40 that any considerable collection was made in the islands, when Hugh Cuming, an English botanical traveler, visited the Philippines and brought back an extensive collection of ferns which were studied by John Smith, of Kew Gardens. Smith published a list of these ferns * which included 297 species, of which he estimated that 100 were new to science. He gave names to his new species but they remained *nomina nuda* until they were described in part by Hooker in *Species Filicum* (1844–1866), and in part by Presl in his *Hymenophyllaceae* (1843) and in his *Epimeliae Botanicae* (1849) and other works. The types of these species are therefore divided between the Royal Herbarium at Kew and the herbarium of the Deutsches Botanisches Institut at Prague. The most complete series of Cuming's collections is at Kew, but extensive duplicate series exist in other herbaria. The types of Haenke's collections are at Prague, where Presl's rich fern collection exists, unmounted, just as its founder left it. A few ferns were collected by Vidal and included in his *Revisión* (1886), and his *Catálogo* (1892) both printed at Manila, but these works contained no additions to the fern flora and their determinations are to say the least of doubtful value.

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* Smith, John. Enumeratio Filicum Philippinarum. Jour. Bot. 3 : 392–422. 1841.

More important were the collections of Professor J. B. Steere, of Michigan University, who visited the islands between 1870 and 1875. The ferns of the Steere collection were worked over at Kew by M. W. Harrington,* who described a few species as new and made numerous additions to the known flora. The originals of the Steere collection are at Michigan University and a fair series of duplicates is at Kew.

A still more important collection of Philippine ferns was made in the years 1890–97 by A. Loher, a Bavarian traveler, which was almost as extensive as the earlier one of Cuming. Dr. H. Christ,† of Basel, studied Loher's collection, and his enumeration comprises 271 species, including many additions to the known flora and a number of new species.

Finally Herr O. Warburg, who has for years made a special study of the flora of the monsoon region, traveled in Luzon and the southern portion of Mindanao and made extensive collections. His ferns were studied by Dr. Christ and are listed in the first volume of *Monsunia*,‡ where Dr. Warburg has also given an exended revision of the species of *Selaginella* of the entire Indo-Pacific region from Japan to Australia. Many species were thus added to the Philippine flora, including quite a number of new species, especially in *Selaginella*.

The fern flora of the Philippines as known to-day embraces over 600 species, and it may be said that collection has only commenced. It is probable that when the area is fully explored the extensive archipelago so lately come into our possession will yield at least half as many more species. In order to furnish our botanical residents and travelers in the Philippines a means of understanding the relations of the fern flora of these islands, at least generically, we have prepared the following synopses of the genera known to exist in the islands, which include many forms widely different either from our own temperate ferns, or even from the ferns of the American tropics. The generic sequence here adopted will be found to differ widely from the treatment given in Hooker and Baker's *Synopsis Filicum* (1874), which unfortunately remains the only hand manual of the ferns of all lands and whose treatment of genera is as irrational as its recognition of specific distinctions is defective, generalized and indefinite. The system here adopted will accord more nearly with the treatment by Dr. Diels in *Die natürlichen Pflanzenfamilien*, which in the main is admirable, suffering lapses to the older system mainly in its treatment of the Cyatheaceae and the genera included under *Polypodium* and *Nephrodium*. In the Hymenophyllaceae we have followed in part the admirable treatment of Presl * which, in the main, was taken up by Van den Bosch, the only other monographer who has made a special study of the group, and which has been as systematically neglected by Hooker and Baker and by Sadebeck, who prepared this family for *Die natürlichen Pflanzenfamilien*. For convenience, references are here made to the *Synopsis Filicum* and *Die natürlichen Pflanzenfamilien*, where the treatment differs from either of the works named.

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* Harrington, M. W. The Tropical Ferns collected by Professor Steere in the years 1870–75. Jour. Linn. Soc. **16**: 25–37. 1877.

† Christ, H. Filices Insularum Philippinarum. Bull. Herb. Boiss. **6**: 127–154, 189–211. *pl. 2–4.* 1898.

‡ Warburg, O. Monsunia, Vol. 1, 1900. Filicinae, by H. Christ, pp. 54–94. *pl. 2;* Rhizocarpaceae, Equisetaceae, Lycopodiaceae and Selaginellaceae, by O. Warburg, pp. 95–136. *pl. 3, 4.*

While the fern flora of the Philippines is only partially known, it is probable that there will be very few additions to the genera as the result of further exploration. With the exception of the Isoetales — usually the last pteridophytes to be collected in any region — all the orders are represented in the Philippine flora and among the Filicales all the families except the rare and unique Matoniaceae; from the known distribution of the two diverse species of this family it is not improbable that it will ultimately find a representative in our domain. Since the present synopsis is intended chiefly to aid in distinguishing generically the ferns that may be collected in the islands, suggestions are given here and there relative to special points to be noted in the field, since in many genera certain portions of the plant show more important diagnostic characters than others and need to be specially noted in the field, particularly in plants too large to be collected entire. A few general features should always be noted and these are here summarized:

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* Presl, C. B. Hymenophyllaceae. Eine botanische Abhandlung. 1–70. *pl. 1–12.* Prag, 1843.

1. In all ferns not over two feet high an entire plant should be secured, but in plants growing in dense crowns the rootstock may well be split lengthwise and several of the leaves removed before drying.

2. In all ferns not over four feet high an entire leaf should be secured if possible attached to the rootstock or to some portion of it. In case of very wide leaves the lower pinnae on one side may be cut away to prevent the too great massing of foliage when the leaf is doubled on itself to make a manageable specimen.

3. In tree-ferns the basal portion of the petiole should always be secured, if possible, attached to the lower pinnules. Where possible the top of the caudex should also be taken. Notes on the character of the leaf-scars should always be made.

4. If the specimen taken does not show whether the leaves are scattered or cespitose this fact should always be included in the notes.

5. In ferns of whatever size, invariably secure some portion of the rootstock, for it nearly always possesses diagnostic characters.

6. In large leaves note whether the lowermost pinnae are larger than the others or are reduced in size and if their laminae stand in the same plane as the rest of the leaf or are set obliquely.

Had the earlier collectors followed such directions instead of taking mere tips of large leaves, or single leaves of smaller ferns wholly without rootstocks, we would now be saved the uncertainty of identifying plants with descriptions based on such scrappy materials.

The six orders represented in the Philippines may be distinguished as follows:

1. Plants of fern-like habit, mostly with broad leaves. 2.
Plants of rush-like habit; foliage reduced to whorls of united scales forming sheaths at the joints of the stems; sporangia borne under peltate shields collected in a terminal cone V. **Equisetales.**
Plants of moss like habit, with 4–10-ranked scale-like or linear leaves, terrestrial or epiphytic; sporangia borne in the axils of ordinary or modified leaves. VI. **Lycopodiales.**

2. Homosporous (spores uniform); all terrestrial or epiphytic except *Ceratopteris*. 3.
Heterosporous (producing minute microspores and larger macrospores); aquatic, rooted or floating; sporangia borne in ovoid or spherical conceptacles (*sporocarps*). IV. **Salviniales.**

3. Sporangia on the under surface of the leaf, borne in boat-shaped or circular conceptacles (*synangia*); eusporangiate; vernation circinate. II. **Marattiales.**
Sporangia borne in sori directly on the veins or exceptionally in spikes or panicles. 4.

4. Vernation erect or inclined; eusporangiate, the sporangia ringless, leathery, opening by a transverse slit, arranged in spikes or panicles. I. **Ophioglossales.**
Vernation circinate; leptosporangiate, the sporangia membranous, usually provided with a ring which opens elastically. III. **Filicales.**

I. OPHIOGLOSSALES

The fleshy plants of this order making up the single family Ophioglossaceae are arranged in four genera.

1. Terrestrial plants. 2.
Epiphytic, pendent from trees; leaf strap-like, bearing a spike near the middle. OPHIODERMA.

2. Sporangia in two-ranked spikes; leaves simple; veins anastomosing. OPHIOGLOSSUM.
Sporangia in panicles; leaves compound; veins free. 3.

3. Panicles lax, the sporangia 2-ranked. BOTRYCHIUM.
Panicles close, spike-like; the sporangia clustered and crested. HELMINTHOSTACHYS.

The members of this family are mostly small plants and the species of *Ophioglossum* especially would be likely to be overlooked. Four species of *Ophioglossum* are already known and the other genera are each represented in the islands by a single species. *Ophioderma* has leaves a yard or more long; it is often united to *Ophioglossum*, but in both habit and structure it is abundantly distinct.

II. MARATTIALES

The members of the tropical family Marattiaceae are mostly large fleshy plants with stout stems rising from ponderous corm-like trunks. There are three genera known from the Philippines:

1. Leaves ternate or palmate; synangia circular, depressed in the center. KAULFUSSIA.
Leaves pinnately compound; synangia oval or boat-shaped. 2.

2. Capsules concrete in boat-shaped synangia. MARATTIA.
Capsules close but not concrete, collected in oval sori. ANGIOPTERIS.

Kaulfussia is represented by a single small species with leaves resembling those of the horse-chestnut. *Marattia* has two with bipinnate or tripinnate leaves eight to fifteen feet long, while *Angiopteris* has four nominal species * nearly as large.

III. FILICALES

The ferns proper with circinate vernation belonging to the leptosporangiate series are represented in the Philippines by several families distinguished as follows:

1. Sporangia opening longitudinally, paniculate (or in *Lygodium* borne singly and covered by scales on narrow projections from the leaves). 2.
Sporangia sessile, borne on a special marginal thread-like receptacle, surrounded by a cup-shaped or bivalved involucre; texture translucent. 7. HYMENOPHYLLACEAE.
Sporangia dorsal or marginal, attached directly to the lamina, usually collected in definite sori. 3.

2. Sporangia nearly globose with a rudimentary ring. 1. OSMUNDACEAE.
Sporangia pyriform with an apical ring. 3. SCHIZAEACEAE.

3. Aquatic; leaves dimorphous; sporangial ring broad or rudimentary. 2. CERATOPTERIDACEAE.
Terrestrial or epiphytic; sporangial ring complete, vertical. 4.

4. Sporangia sessile, wedge-shaped, radially arranged; stems simple or (in all Philippine species) pseudo-dichotomous. 4. GLEICHENIACEAE.
Sporangia sessile or short-stalked in rounded sori; usually arborescent. 5. CYATHEACEAE.
Sporangia usually long-stalked; herbaceous, rarely with an arborescent caudex. 6. POLYPODIACEAE.

To the above families belong the largest number of the ferns not only of the Philippines but of the entire world. While the greater part of the Philippine ferns bear a general resemblance to those of temperate regions there are many curious forms particularly among the epiphytic species that are quite unique and widely different from our ordinary conception of a fern. The two families Gleicheniaceae and the tree-ferns (Cyatheaceae) are not represented in temperate America at all, and the filmies (Hymenophyllaceae), rare with us, are abundantly represented in the Philippines as in all tropical regions.

FAMILY I. OSMUNDACEAE

This family is represented in the Philippines by a single species of *Osmunda*, though it is quite possible that others may be found.

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* Synopsis Filicum reduces all the forms of *Angiopteris* to a single species, but Presl defined ten, and DeVries and Harting who monographed the family in 1853 recognized sixty! From the fleshy nature of the plants it is a genus that requires field study, and description or even identification from herbarium material is necessarily defective.

Family 2. Ceratopteridaceae

The aquatic *Ceratopteris*, apparently a tropical cosmopolite, is the only known representative of this family.

Family 3. Schizaeaceae

Four genera of this family have been found in the archipelago; they may be distinguished as follows:

1.	Sporangia solitary, covered by scales, arranged on marginal teeth of the leaves; leaves pinnate; stems twining.	Lygodium.
	Sporangia in distichous spikes; plants small, erect.	2.
2.	Leaves narrow, simple, grass-like.	3.
	Leaves broader, flabellately forked.	Lophidium.
3.	Spikes in a penicillate tuft.	Actinostachys.
	Spikes in a pinnate cluster.	Schizaea.

The last three genera, which have usually been united under *Schizaea*,* are inconspicuous plants represented in the Philippines by one species each. *Lygodium* is represented by six species which are conspicuous climbing ferns very unlike their single diminutive representative in our Eastern States.

Family 4. Gleicheniaceae

This family is well represented in the Philippines by eleven species of *Dicranopteris*; † while this number is nominal it is likely not to be excessive, judging from the diversity of species in other tropical regions. The species are wide-spreading, often forming tangled thickets, and are easily recognized by the pseudo-dichotomous branching. They are very difficult to prepare for the herbarium and the greatest care should be taken to secure representative material, since the apical portions of a branch may be quite unlike the lower part of the same plant. By all means the lowest forking should be included in the specimen.

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* In case the members of this alliance are grouped as a single genus it must bear the name *Lophidium*, the oldest available name for a member of this group. The three genera, however, are very homogeneous groups and may best be treated as above.

† The § *Mertensia* of Synopsis Filicum has been thought by many, commencing with Willdenow, to be worthy of generic rank, and has often been kept distinct from the typical Australasian species of *Gleichenia*. The name *Mertensia*, however, is not available since there is an earlier *Mertensia* in the Borraginaceae. *Dicranopteris* Bernh. is available for this group and was proposed for what has usually been known as *Gleichenia dichotoma* (*Polypodium dichotomum* Thunb.). *Mecosorus* Hassk. was a later name proposed by its author because of the preoccupation of *Mertensia*.

FAMILY 5. CYATHEACEAE

The tree-ferns of the Philippines do not appear to have been adequately collected, but the same is true of the family everywhere. They are not a suitable subject for ordinary herbarium study and should be specially prepared as already noted above. The characteristic armature or vestiture of the leafstalks should always be secured and if possible a section of the caudex. The genera represented in the Philippines are as follows:

1. Sori marginal; indusium coriaceous, 2-valved; herbaceous species. CIBOTIUM.
Sori dorsal; tree-ferns. 2.
2. Indusium inferior, cup-shaped. CYATHEA.
Indusium inferior, half cup-shaped. HEMITELIA.
Indusium wanting. ALSOPHILA.

Cibotium is represented by *C. Barometz*,[*] often cultivated in American conservatories, and is not a tree-fern. The other genera form the genuine tree-ferns and include thirteen known species, four in *Cyathea*, eight in *Alsophila* and a single *Hemitelia*.

FAMILY 6. POLYPODIACEAE

The true ferns are the most abundant of any family and form three fourths of the fern flora of the islands, which is their usual proportion. The number of genera is so large that we can best distinguish them in their tribal relations separately:

1. Sporangia scattered over the under surface of the leaf-blade in a uniform layer.[†] 2.
Sporangia dorsal or marginal, accumulated in definite sori. 3.
2. Leaves of two sorts; a shield-like basal leaf attached to the surface of the substratum and a furcate spreading one with localized sporangial surfaces. 1. *Alcicornieae.*[‡]
Leaves approximately uniform; sporangia covering entire leaves or pinnae. 2. *Acrosticheae.*
3. Sori marginal, continuous or interrupted, covered by a more or less modified portion of the leaf-margin.[‡] 3. *Pterideae.*
Sori dorsal, or at most submarginal, with or without indusia. 4.

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[*] Included under *Dicksonia* in *Synopsis Filicum*.

[†] Certain Dryopterideae with confluent sori may be sought here. *Cf. Polybotrya*, *Anapausia*, *Egenolfia*, etc. Their habit is distinctively aspidioid, and lacks the jointed leaf-stalks of the Acrosticheae.

[‡] We propose this tribal name for the "stag-horn ferns," believing their unique habit should separate them from the Acrosticheae with which they have usually been associated. The name comes from *Alcicornium* Gaud. (1826), which is an older name than *Platycerium*.

[‡] The indusium is wanting in *Notholaena*.

4. Sori elongate-linear. 5.
Sori round or oval. 7.

5. Sori sunken in grooves. 3. *Vittarieae.*
Sori superficial. 6.

6. Indusium normally present (wanting in *Coniogramme* and *Hemionitis*). 6. *Asplenieae.*
Indusium wanting. Certain anomalous *Polypodieae.*

7. Leaves and primary venation fan-shaped; secondary venation anastomosing; indusium wanting. 7. *Dipterideae.**
Leaves and venation normally pinnate. 8.

8. Indusium superior or wanting. 9.
Indusium inferior, rupturing above the sorus. 10. *Woodsieae.*
Indusium attached internally, opening toward the leaf-margin (wanting in *Monachosorum*). 11. *Davallieae.*

9. Leafstalks jointed at their attachment with the rootstock, leaving definite scars when they separate. 10.
Leafstalks continuous with the rootstock; sori dorsal or terminal on the veins, normally indusiate. 8. *Dryopterideae.*†

10. Indusium wanting; sori dorsal or terminal. 4. *Polypodieae.*
Indusium present; sori near the base of the veins. 9. *Oleandreae.*

Tribe 1. Alcicornieae

This tribe is represented in the islands by two species of staghorn fern (*Alcicornium*), characterized by the cordate basal sterile leaves, and the single species of *Cheiropleuria*, with linear sporophyls and two-lobed foliage. Both are epiphytic ferns.

Tribe 2. Acrosticheae

About five species of *Elaphoglossum* with simple free-veined leaves, and a single species of *Acrostichum* with pinnate leaves and anastomosing veins make up the known representation of this tribe in the Philippines. The dense masses of sporangia spread in a uniform layer over the leaves form a character easily recognized.

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* *Dipteris* in *Synopsis Filicum* was placed in the genus *Polypodium*, with which it has no near alliance, and in *Die natürlichen Pflanzenfamilien* it is placed in the Aspidieae, in which it finds an equally insecure resting place. It is a unique fern without near relations and we place it in a distinct tribe.

† Since *Aspidium* as a generic name must be retired to the oblivion of synonymy, it is desirable that we have a tribal name which is derived from a typical or characteristic genus contained in it. We therefore substitute *Dryopterideae* for *Aspidieae* heretofore in use.

Tribe 3. Vittarieae

The three Philippine genera of this tribe may be characterized as follows:

1. Leaves narrow, grass-like; sporangia in one or more continuous lines. 2.
   Leaves broader; sporangia in broken lines often following the anastomosing of the veins. ANTROPHYUM.
2. Sporangial line medial, single. MONOGRAMMA.
   Sporangial lines double, marginal or submarginal. VITTARIA.

Eight nominal species of *Antrophyum*, six of *Vittaria* and one *Monogramma* have been reported from the Philippines. All are epiphytic in habit.

Tribe 4. Polypodieae

Two distinct series are represented in this tribe which normally includes the species lacking an indusium. In one series the sori are linear, in the other they are normally round ranging to oval. The genera may be distinguished as follows:

1. Sori linear, parallel to the midrib or margin. 2.
   Sori linear, oblique to the midrib; veins anastomosing. SELLIGUEA.
   Sori round or oval. 5.
2. Leaves simple. 3.
   Leaves pinnate. 4.
3. Leaves dimorphous, the sporophyls narrow. DRYMOGLOSSUM.
   Leaves uniform, the apex contracted and bearing the sporangia. BELVISIA.[*]
4. Sori median, between midrib and margin. TAENITIS.
   Sori finally covering the entire under surface. PLATYTAENIA.
5. Under surface of leaf densely covered with stellate hairs. CYCLOPHORUS.[†]
   Under surface smooth or barely scaly. 6.
6. Veins free. POLYPODIUM.
   Veins anastomosing. 7.
7. Basal leaves unlike the sporophyls, forming a nest-like cluster at the base of the plant. DRYNARIA.
   Leaves normally uniform. 8.
8. Sori dorsal, confined to the veins. 10.
   Sori dorsal, extending to the parenchyma. 9.
   Sori terminal on the veins and marginal on the leaf; sporophyls contracted; rootstocks much swollen. LECANOPTERIS.
9. Leaves pinnate. PHOTINOPTERIS.
   Leaves pinnatifid with decurrent segments. DRYOSTACHYUM.

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[*] *Belvisia* Mirbel, antedates *Hymenolepis* Kaulf. adopted in *Die natürlichen Pflanzenfamilien* for this genus.

[†] *Cyclophorus* Desv. was perfectly well characterized and typified, and there is no excuse for using the later *Niphobolus* Kaulf.

10. Areolae regular, with a single free included veinlet which is directed outward. GONIOPHLEBIUM.*

Areolae small, irregular, with free veinlets spreading in various directions. PHYMATODES.*

Selliguea, joined with *Gymnogramme* in *Synopsis Filicum*, and united with *Polypodium* in *Die natürlichen Pflanzenfamilien*, is represented by eight species. *Drymoglossum*, *Dryostachyum*, *Taenitis* and *Platytaenia* have each a single representative in the Philippine flora, the last two in fact being monotypic genera.

Belvisia, included under *Acrostichum* in *Synopsis Filicum*, has two representatives. The remaining genera recognized above form a part of the unnatural genus *Polypodium*, as recognized in *Synopsis Filicum*. *Lecanopteris* and *Photinopteris* are represented each by a single species ; *Cyclophorus* has sixteen nominal species, though not all reported have been taken up by Giesenhagen in his admirable monograph of the genus. This, however, is not an exhaustive treatment from a strictly taxonomic standpoint, containing some new things not properly correlated with that which is old. *Drynaria* similarly has ten nominal species, but the genus has never had a careful revision and all the species require very careful study afield. *Goniophlebium* has four species including the peculiar simple-leaved *Polypodium nummularium* on which Presl based his genus *Crypsinus* perhaps with good reason. *Polypodium* and *Phymatodes* have the largest representation in the islands, the former with nineteen nominal species and the latter with thirty-eight. It is probable that both these genera will receive extensive additions, particularly among the smaller epiphytic species that from their habitat longer evade detection. Such at least has been the experience in other tropical regions. Taken as a whole this tribe is one of the largest as well as one of the most characteristic groups of the Philippine fern flora.

Tribe 5. Pterideae

Maidenhair ferns are apparently less common in the Philippines than in most tropical regions and the entire tribe to which they belong with the exception of a single genus has a comparatively slight representation in the island flora. The several genera may be distinguished as follows:

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* The above synopsis follows exactly the lines noted in *Die natürlichen Pflanzenfamilien*, except that *Goniophlebium* and *Phymatodes* are there included under *Polypodium*, where in our judgment less attention has been given to venation than elsewhere in the work.

1.	Sporangia attached to the under surface of marginal lobes; leafstalks black and shining.	ADIANTUM.
	Sporangia rising from a marginal vein-like receptacle.	2.
	Sporangia rising from the ends of unconnected veins; sori continuous or interrupted.	5.
2.	Indusium double, the inner membranous, extrorse.	3.
	Indusium single.	4.
3.	Leafstalks with several fibrovascular bundles.	PTERIDIUM.
	Leafstalks with a single semicircular fibrovascular bundle.	PAESIA.
4.	Spores sphaero-tetrahedral.	PTERIS.*
	Spores bilateral; leaves glaucous with auricled pinnae.	HISTIOPTERIS.
5.	Leaves uniform.	6.
	Leaves dimorphous.	8.
6.	Indusium continuous; stems black, polished.	DORYOPTERIS.
	Indusium interrupted.	7.
	Indusium wanting.	NOTHOLAENA.
7.	Sori distant in sinuses of leaf.	HYPOLEPIS.
	Sori crowded, more or less confluent.	CHEILANTHES.
8.	Leaves simply pinnate.	PLAGIOGYRIA.
	Leaves decompound.	ONYCHIUM.†

Of the above genera *Paesia* and *Histiopteris* are each represented by a single Philippine species, *Onychium*, *Pteridium*, *Doryopteris*, *Hypolepis*, and *Notholaena* by two each, and *Cheilanthes* and *Plagiogyria* by three each. *Adiantum* has six representatives, of which one and possibly two are introduced species, while over twenty species of *Pteris* have been reported. The latter genus, and particularly its larger species, require careful field study; the peculiar tripartite branching of the larger species should be specially noted.

Tribe 6. Asplenieae

Next to the Polypodieae this tribe forms the most extensive portion of the Philippine fern flora; the thirteen genera represented may be distinguished as follows:

1.	Sori parallel to the midribs.	2.
	Sori oblique to the midribs.	5.

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* We have taken up *Pteris* as treated by Diels, *l. c.*, including species with both free and anastomosing veins. These have been separated by Presl and others, and further study will doubtless prove that they were correct.

† Diels following Prantl unites this with *Cryptogramma*, for which we can see no valid reason.

2. Indusium wanting; plants climbing; leaves dimorphous. STENOCHLAENA.
Indusium present; plants mostly terrestrial. 3.

3. Leaves uniform. 4.
Leaves dimorphous; sori intramarginal; caudex sometimes arborescent. STEGANIA.[*]

4. Veins anastomosing between the sori and the margin. WOODWARDIA.
Veins free between the sori and the margin. BLECHNUM.

5. Indusium wanting. 6.
Indusium present. 8.

6. Veins free. 7.
Veins anastomosing. HEMIONITIS.[†]

7. Sori forked, with the forking of the veins. CONIOGRAMME.[‡]
Sori simple, linear. SYNGRAMMA.[‡]

8. Veins free. 9.
Veins anastomosing. 10.

9. Sori confined to one side of a vein, linear or slightly curved. ASPLENIUM.[§]
Sori curved or horseshoe-shaped, crossing to both sides of the veins. ATHYRIUM.[§]
Sori double, the indusia opening on both sides of some of the veins. DIPLAZIUM.
Sori rising from a special receptacle midway between veins; indusia attached to the veins, opening toward each other. TRIPHLEBIA.

10. Veins connected only at their apices; leaves simple, densely clustered. THAMNOPTERIS.[‖]
Veins forming regular areolae. CALLIPTERIS.[¶]

Woodwardia, *Hemionitis* and *Coniogramme* are each represented in the Philippines by a single species, *Triphlebia* and *Syn-*

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[*] Diels unites this with *Blechnum*, although under the name *Lomaria* the genus is held as distinct even in *Synopsis Filicum*. The name *Struthiopteris* must hold for the European and North American representative of the genus (*S. Spicant*) and *Lomaria* had for its type a member of another genus, so must be replaced by *Stegania* R. Br., if generic distinctness from the North Temperate representatives is maintained.

[†] *Hemionitis* is associated in *Die natürlichen Pflanzenfamilien* with the Pterideae, with which it appears to have no near relationship; it must either form a tribe by itself or be associated here with its nearest but not very close allies.

[‡] *Coniogramme* and *Syngramma* form a part of the heterogeneous *Gymnogramme* of *Synopsis Filicum*: Diels associated them with the Pterideae, for which we can see no warrant.

[§] It is still an open question as to what we shall consider the generic types of these two genera; they are adopted here tentatively in their usually accepted sense.

[‖] The "bird's nest fern"; united with *Asplenium* by both Diels and Baker.

[¶] The earlier name for *Anisogonium* Presl. Diels unites it with the free-veined *Diplazium* and both are joined as sections of *Asplenium* in *Synopsis Filicum*. *Allantodia* of *Synopsis Filicum* is also reported from the Philippines, but the name cannot hold for the species to which it is assigned and the genus is not clearly distinguished from *Callipteris*.

gramma by two each, *Stenochlaena*, *Thamnopteris* and *Athyrium* by four each, *Stegania* by five, and *Blechnum* by six ; the larger genera are *Callipteris* with twelve species, *Diplazium* with twenty-one, and *Asplenium* with thirty-three. These numbers, however, represent nominal species and yet are not likely to be much reduced, and will be varied only by future discoveries.

Tribe 7. Dipterideae

This tribe is represented only by a single species of the curious fan-shaped *Dipteris*, perhaps one of the most unique among the ferns of the islands. Its leaves are often two or three feet broad.

Tribe 8. Dryopterideae

Related to our wood-ferns are a large number of species in all tropical regions and the Philippines come in for their share. The sixteen genera are distinguished as follows:

1. Veins normally free, simple, forked, or pinnately branched. 2.
Veins connivent, *i. e.*, the branches from contiguous pinnate groups uniting to form one or more arches. 4.
Veins copiously anastomosing. 6.

2. Leaves dimorphous; sori extending from the veins to the parenchyma so as to appear continuous. 11.
Leaves uniform or nearly so. 3.

3. Indusium wanting; margins of segments plane. PHEGOPTERIS.
Indusium circular, peltate. 8.
Indusium oval, attached by a central axis to a thickened linear receptacle. DIDYMOCHLAENA.
Indusium cordate-reniform, attached by the sinus; veins distinct. DRYOPTERIS.

4. Indusium wanting. 5.
Indusium cordato-reniform, attached by the sinus. CYCLOSORUS.

5. Sori round, punctiform. GONIOPTERIS.
Sori elongate on the more or less parallel transverse arches. MENISCIUM.

6. Indusium wanting. 7.
Indusium cordato-reniform, attached by the sinus. 9.
Indusium orbicular, centrally peltate. 10.

7. Leaves dimorphous; sori extending to parenchyma so as to appear continuous. 12.
Leaves uniform. ARCYPTERIS.[*]

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[*] The genus *Dictyopteris* Presl (1836) is antedated by a genus of the same name among the algae. We therefore propose the name **Arcypteris**, with the same meaning. It is not the exact equivalent of *Dictyopteris* Presl, the first species of which was *Polypodium attenuatum* R. Br., which does not belong to the § *Dictyopteris* as taken up by *Synopsis Filicum*. *Aspidium difforme* Blume (Enum. Pl. Jav. 160. 1828) may be considered as the type of *Arcypteris*.

8. Pinnae continuous with the rachis; texture firm, more or less coriaceous. POLYSTICHUM.
Pinnae articulated with the rachis, easily caducous; texture thin herbaceous. CYCLOPELTIS.

9. Areolae irregular, without free veinlets. PLEOCNEMIA.
Areolae provided with free recurrent veinlets. SAGENIA.

10. Areolae regular; included veinlets straight, directed towards the margins of the segments. CYRTOMIUM.
Areolae irregular, fine; included veinlets often branched and recurrent. TECTARIA.

11. Rootstock short. EGENOLFIA.
Rootstock widely climbing. POLYBOTRYA.

12. Areolae few, without free included veinlets. STENOSEMIA.
Areolae copious, with free included veinlets. ANAPAUSIA.*

The disposition of these genera by Hooker and Baker and by Diels is so diverse that it can be best represented in tabular form:

Genera here accepted	Number of Philippine species reported	Equivalent genera in *Die natürlichen Pflanzenfamilien*	Equivalent genera in *Synopsis Filicum*
Phegopteris	9	Nephrodium	Polypodium
Polystichum	9	Polystichum	Aspidium
Cyclopeltis	1	Cyclopeltis	Aspidium
Didymochlaena	1	Didymochlaena	Didymochlaena
Dryopteris	44	Nephrodium	Nephrodium
Cyclosorus	24	Nephrodium	Nephrodium
Goniopteris	6	Nephrodium	Polypodium
Meniscium	2	Nephrodium	Meniscium
Arcypteris	5	Nephrodium	Nephrodium
Pleocnemia	5	Nephrodium	Nephrodium
Sagenia	9	Aspidium	Nephrodium
Cyrtomium	1	Polystichum	Aspidium
Tectaria	7	Aspidium	Aspidium
Egenolfia	1	Polybotrya	Acrostichum
Polybotrya	5	Polybotrya	Acrostichum
Stenosemia	1	Stenosemia	Acrostichum
Anapausia	12	Gymnopteris	Acrostichum

Tribe 9. Oleandreae

This tribe is represented in the Philippines by four nominal species of *Oleandra*, the only genus in the tribe. Their satiny luster renders them peculiarly attractive among ferns.

Tribe 10. Woodsieae

This tribe is represented in our eastern possessions only by one species of *Diacalpe*.

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* These have been usually placed in *Gymnopteris*, but that genus was monotypic as originally founded and based on a plant of a wholly different alliance.

Tribe 11. Davallieae

The eight genera represented may be distinguished as follows:

1. Pinnae one-sided: indusium double, the inner membranous, the outer formed of the more or less changed leaf-margin. LINDSAEA.
   Pinnae developed on both sides of midrib, though not always equally. 2.

2. Indusium attached only at base. 3.
   Indusium attached on three sides. 4.
   Indusium wanting; sori subterminal on the veins. MONACHOSORUM.

3. Pinnae jointed to the rachis. NEPHROLEPIS.
   Pinnae not jointed; leaves jointed to the rootstock. HUMATA.
   Pinnae not jointed; leaves not jointed to the rootstock. SACCOLOMA.

4. Leaves jointed to the rootstock. DAVALLIA.
   Leaves not jointed to the rootstock. 5.

5. Leaf-lobes as long as indusium and both uniting in a special cup beneath the sorus. DENNSTAEDTIA.
   Leaf-lobes slightly modified, longer than the indusium. 6.

6. Sorus with a receptacle containing tracheids; leaves scattered on a creeping rootstock. MICROLEPIA.
   Sorus without a tracheidal receptacle; leaves clustered. ODONTOSORIA.

The Malaysian region is the home of certain groups of the davallioid ferns; *Humata* is represented by twelve species; *Davallia* also by twelve species, of which six belong to the § *Odontoloma*, sometimes recognized as a genus; *Odontosoria* by a single species, and *Microlepia* by nine; all the foregoing are included in the genus *Davallia* in *Synopsis Filicum.* Of the other genera *Nephrolepis* has eight nominal Philippine species, a number which may be modified, since the genus is sadly in need of a revision; *Lindsaea* has seventeen, *Dennstaedtia* has four, and *Monachosorum* and *Saccoloma* each one.

FAMILY 7. HYMENOPHYLLACEAE

Following the usual treatment the filmy ferns are grouped in two genera representing the primary divisions in the following synopsis. We believe, however, that many of the genera established by Presl are as clearly marked natural groups as can exist among the ferns, and in the following treatment we have taken up such of Presl's genera as occur in the Philippines, believing that others represented in tropical America and elsewhere represent equally natural groups.

The Philippine genera are as follows:

1. Indusium tubular; receptacle filiform exserted. (*Trichomanes* Syn. Fil.) 2.
Indusium 2-valved, formed of two divided laminae of the leaf; receptacle shorter than the indusium or barely protruding. (*Hymenophyllum* Syn. Fil.) 6.

2. Margin of the indusium entire. 3.
Margin of the indusium 2-lipped. 5.

3. Receptacle terminating in a rounded head. CEPHALOMANES.*
Receptacle uniformly terete. 4.

4. Leaves and indusia bordered by rows of minute cells. ABRODICTYUM.†
Leaves of uniform texture not bordered. TRICHOMANES.

5. Indusium contracted below the lips, bordered by the tissue of the leaf. DIDYMOGLOSSUM.‡
Indusium lateral, subpedicellate, not contracted nor bordered. MERINGIUM.§

6. Receptacle clavate; leaves smooth; sporangia sessile. HYMENOPHYLLUM.
Receptacle globose-thickened at the summit; leaves often covered or margined with simple or stellate hairs, sometimes smooth; sporangia stipitate. SPHAEROCIONIUM.||

Of the above genera *Cephalomanes*, *Abrodictyum*, and *Meringium* are each represented by a single species, *Sphaerocionium* and *Didymoglossum* by six each; *Hymenophyllum* still has a residue of fourteen species, and *Trichomanes* a still larger one of twenty-four. There has been no modern monograph of this family, so that these numbers are likely to be varied greatly aside from future additions to the flora.

IV. SALVINIALES

Both families of this order are represented in the Philippines: the floating Salviniaceae by a single species of *Azolla*, and the rooting Marsileaceae by a single species of *Marsilea* with the usual

---

* *Cephalomanes* Presl, Hymenophyllaceae, 17. *pl. 5.* 1843. Monotypic; based on *C. atrovirens* Presl (Luzon, *Cuming, no. 169*); there was evidently a mixture in this number, for Hooker in commenting on Presl's genera says that his plant under that number is *Trichomanes Javanicum*. Presl later defends his genus in vigorous language and adds other species, and the genus was accepted by Van den Bosch.

† *Abrodictyum* Presl, Hymenophyllaceae, 20. *pl. 7.* 1843. Monotypic; based on *A. Cumingii* Presl (Luzon, *Cuming, nos. 208, 358*).

‡ *Didymoglossum* Desv. Ann. Soc. Linn. Paris, 6: 330. 1827. Based on *Trichomanes muscoides* Sw. (first named) and seven other species.

§ *Meringium* Presl, Hymenophyllaceae, 21. *pl. 8, f. B.* 1843. Based on two species, of which *M. Meyenianum* Presl (Luzon, *Meyen*) is named as type.

|| *Sphaerocionium* Presl, Hymenophyllaceae, 33. *pl. 4, f. B; pl. 10, f. B, C.* 1843. Based on *Hymenophyllum hirsutum* Sw. (first named) and numerous other species.

quadripartite foliage characteristic of the genus. The species of *Marsilea* grow in wet places and often resemble in habit small plants of *Oxalis*.

V. EQUISETALES

This order of a single family has at present one known representative in the Philippines, *Equisetum debilis*, also found in southeastern Asia.

VI. LYCOPODIALES

All three of the families of this order are represented in the Philippines. They may be easily recognized as follows:

1.	Spores minute, of one sort.	2.
	Spores of two sorts, minute microspores and larger macrospores; leaves (in all Philippine species) 4-ranked, of two sizes.	3. SELAGINELLACEAE.
2.	Sporangia unilocular.	1. LYCOPODIACEAE.
	Sporangia 2–3-locular.	2. PSILOTACEAE.

The Lycopodiaceae are represented by thirteen species of *Lycopodium*, two of which are said to be species of the temperate or subboreal region of the United States, a statement which appears scarcely credible.

The Psilotaceae are represented by *Psilotum nudum* with leaves reduced to mere rudiments, and trilocular sporangia, and *Tmesipteris Tannensis* with oval leaves nearly an inch long and bilocular sporangia. The Selaginellaceae are represented by thirty-three species of *Selaginella*, the larger part of which have been added through the labors of Dr. Warburg.

SUMMARY

Orders	*Families*	*Genera*	*Species*
Ophioglossales	1	4	7
Marattiales	1	3	7
Filicales	7	91	568
Salviniales	2	2	2
Equisetales	1	1	1
Lycopodiales	3	4	48
Totals	15	105	633

The fern flora of the Philippines is evidently related on the one hand to that of Formosa and the Asiatic continent, and on the other to that of the more southerly islands of Celebes and Borneo; the extensive recent additions to the fern flora of the latter island through the discoveries of Bishop Hose open up a series of interesting distributional problems relative to the southern islands of the Philippine group which have never yet been explored botanically. It is hoped that some American residents in the Philippines will become interested in the ferns of the islands and make extended studies of their interesting pteridophyte flora. We shall be only too glad to render any assistance in specific identification that may be sought in the hope that our knowledge of the fern flora of this prolific region may be thereby extended.

COLUMBIA UNIVERSITY, 1 November, 1903.

Since the above article was in print I have learned of the publication of a paper by Mr. E. D. Merrill on the botanical work already accomplished in the Philippines, said also to give an account of the existing herbaria in the archipelago.—L. M. U.

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Anatomy and Physiology of Baccharis genistelloides

BY ELSIE M. KUPFER

Baccharis genistelloides Pers. is an inhabitant of the mountains of Peru, growing in dry places at an altitude of about 1200 meters. It has several well-marked varieties which apparently spread north into Ecuador, and south and east into Brazil. The typical form is a slightly shrubby plant of extremely peculiar appearance. The leaves are atrophied, being represented by minute scales scarcely more than 2 mm. in length; and the work of photosynthesis is assumed by conspicuous wings which stand at three equal angles from each other. The scales are arranged in three orthostichies, and two wings originate from the base of each scale. One of these wings runs through only one internode and terminates at the margin of the scale below; the other, in each case, runs through two internodes until it is similarly stopped. This alternation of a long and a short wing in each orthostichy, as well as the fact that the wings (following the phyllotaxy) twist spirally, accounts for the curious appearance of the plant represented in *f. 1*.

While the shoot is almost uniformly leafless in the upper portion, usually one, two, or even several normal leaves are to be found near its base. They are of moderate size, obovate and somewhat thickened (*f. 2* and *3*). The genus *Baccharis* is a large, and as far as leaf-form is concerned, a heterogeneous one. The leaves of many species, *e. g.*, *B. floribunda* and *B. trinervis*, are large, thin and smooth; others, as those of *B. alpina* and *B. microphylla*, are minute and thickened; *B. aphylla* and *B. gracilis* have only narrow phyllodes; and, finally, *B. genistelloides* and *B. fastigiata* are devoid of foliar leaves. The leaves of several of the species, however (and it is significant that these are generally South American species), particularly *B. dioica* and *B. cassinaefolia*, closely resemble in shape, size and texture the juvenile leaves of *B. genistelloides*. There is every reason, then, it seems to me, for considering this form as that of the ancestral type.

The seeds, unnamed, were brought from Peru by Mr. de Lautreppe in 1900 and planted in the New York Botanical Garden. Because of the ignorance as to their identity, little attention was given to the plants until they had attained a considerable size; so that unfortunately none of the early stages has been observed. At the present time, in the beginning of their third year, the plants are about 1 meter high. The stems near the base are secondarily thickened, and the wings there are either much thickened or have been entirely lost. Several of the plants flowered in February, 1902, and again in December, 1903; but although the flowers were pollinated, the seeds produced were exceedingly minute and failed to germinate.

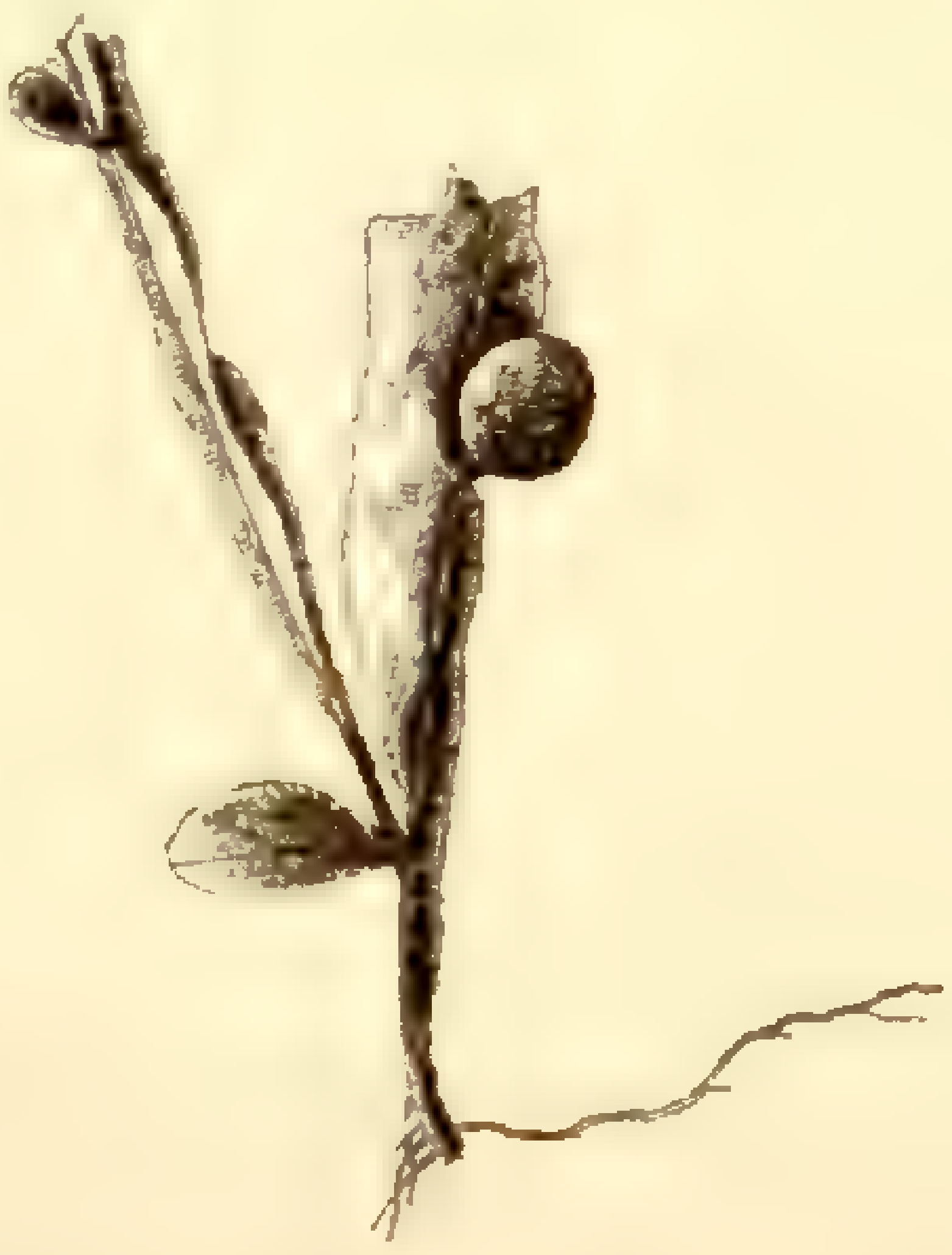

FIG. 2. Shoot from base of plant of *Baccharis genistelloides*, showing leaves.

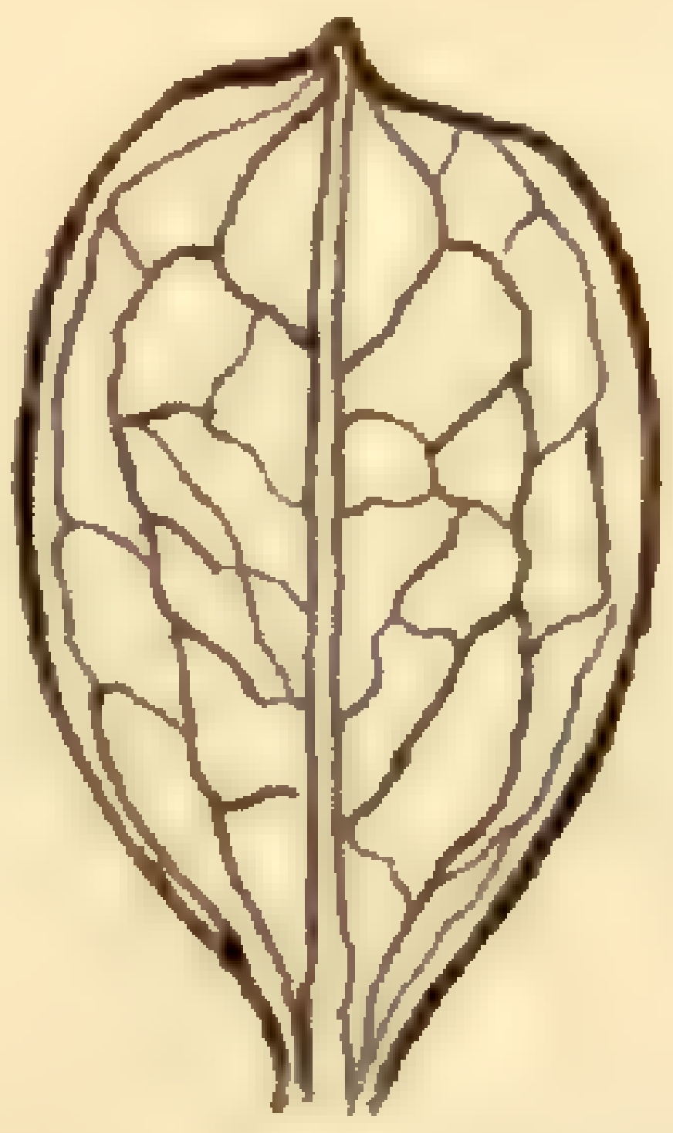

FIG. 3. Single leaf of *Baccharis genistelloides*, natural size.

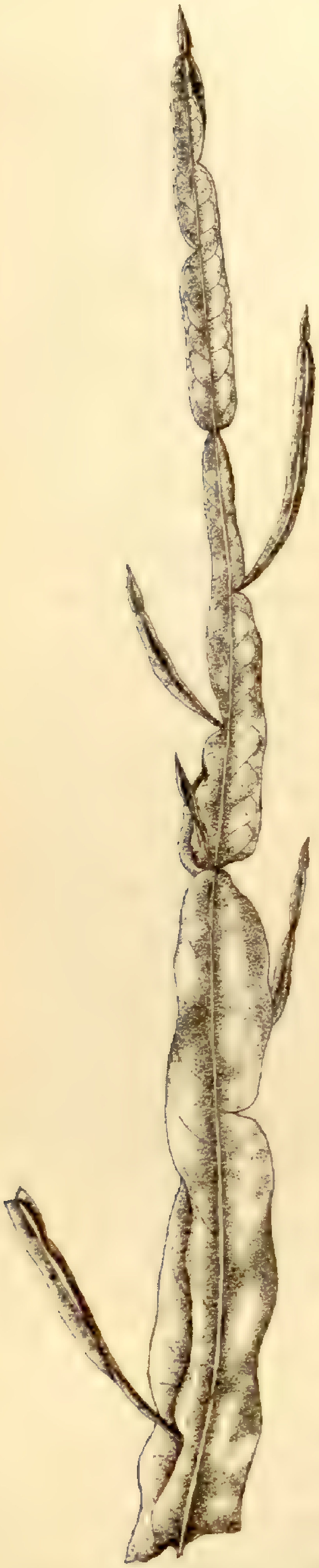

FIG. 1. Shoot of *Baccharis genistelloides.*

Noteworthy adaptations to an environment both of strong light and excessive dryness come to light on an examination of the anatomy and physiology of the plant.

THE EPIDERMAL SYSTEM

The protective system of the plant is very well developed. There is a considerable covering of wax over the whole plant (cf. *f. 9*). In addition, the epidermal cells are cuticularized both without and within; and particularly in the younger portions, the surface is covered with peculiar hairs, of which usually only the end-cells project above the wax. The stomata are exserted and are apparently sensitive. The *wax* is laid down in the form of irregular plates fitted together into a sort of mosaic. In the younger portions, to about 3–7 cm. back of the tip, the waxy covering is very thick, while the outer layers are shed in the form of powdery scales. Its very ready solubility in ether indicates its fatty nature. The *cutin* is present in a layer over the entire plant even up to the very tip of the growing point, though, naturally, it has less thickness here than in the older parts of the plant. The surfaces of the leaves present on the lower parts of the plant are more heavily cutinized than either the wings or the stem.

The *hairs* almost always arise in pairs from two adjacent epidermal cells. In most of the members of this family, as Vesque,* whose observations have been confirmed by more recent investigators, points out, two kinds of hairs are to be found: glandular hairs and mechanical hairs. Both kinds are present in this plant. The gland-hairs, which are composed of double series of from 3–5 cells each, differ from those mentioned by Vesque and Solereder † in that all but the end-cells contain chlorophyl. The cutin is but slightly raised by the not very abundant secretion, the nature of which has not been any more definitely determined than that it is odorless and soluble in ether (*f. 4*). That the secretion of wax is to be assigned to the epidermal cells in general, and not particularly to these hairs, seems probable from the fact that few or none of the hairs are to be found on the older portions of the plant, where, nevertheless, the wax is abundant.

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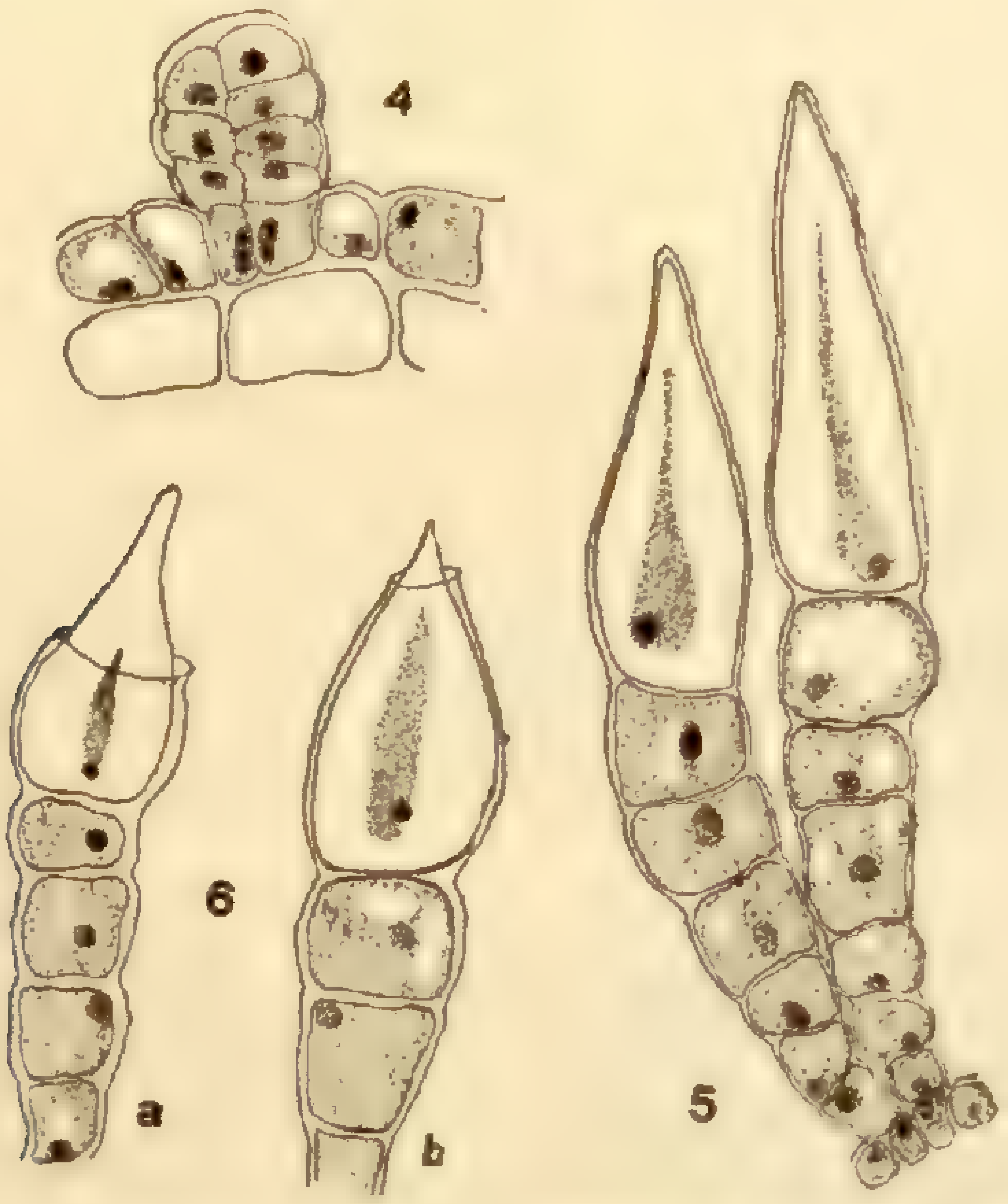
* Vesque, T. Caractères des * * * Gamopétales. Ann. Sci. Nat. Bot. VII. 1: 183. 1885.

† Solereder, H. Systematische Anatomie der Dikotyledonen. 515 ff. 1899.

The whip-hairs, too, seem to differ from the types of Vesque in that they are also, as a rule, bicollateral. They are thus apparently homologous with the gland-hairs. The early condition of the two kinds of hairs is very similar, the only difference being that the whip-hairs are from the beginning devoid of chlorophyl. In the adult condition, however, they are entirely separated from each other. The enormously enlarged end-cells have walls so highly thickened that the cell-lumen is almost obliterated (*f. 5*). The developing whip-hairs are cutinized almost from the start. When fully formed they are also uniformly covered with cutin, but there is a stage in their growth in which the base only of the end-cells is surrounded by a collar of cutin, while the thickened cellulose wall of the upper part shows prominently above and through it (*f. 6 a* and *b*). Probably the cell in its period of hypertrophy breaks through its cutin covering, which is reëstablished after growth has ceased. The two whip-hairs often fail to develop simultaneously, so that a pair is frequently found, one of which is still in its prime, while the other consists of only shriveled empty cells. As far as has been determined, new hairs of either kind are not developed much below 5–6 cm. from the tip. As some also drop entirely off, the hairs on the older portions are very scattered and frequently consist of only the shriveled cells.



Hairs of *Baccharis genistelloides*. FIG. 4. Gland-hair. FIG. 5. Two whip-hairs. FIG. 6, *a*, *b*. Developing whip-hairs.

It is difficult to determine the function of either kind of hairs, if they have any. In the younger parts, where alone the hairs are plentiful, they are often entirely embedded in the wax. The gland-cells are usually thickly covered, while occasionally part of the end-cell of the whip-hair protrudes beyond. Of what use can a secretion be, the escape of which is entirely prevented? In the cases among the Compositae in which the whip-hairs are found, they are usually present as Vesque shows as a tomentum. Probably here, as in *Chrysoma paucifiosculosa* described by Professor Lloyd, they are functionless.*

The *stomata* are evidently of a motile type (*f. 7*). They are provided with distinct accessory cells, so that this plant adds another to the list of composites so provided, although Benecke † declares these cases rare. Both upper and lower walls taper into very finely pointed ridges. No trace of a hinge has been discovered by me, but the cutin seems thinner at the junction of the guard and accessory cell. The accessory cells raise the stomata somewhat above the level of the epidermis. They are more exserted on the stem than on the wing.

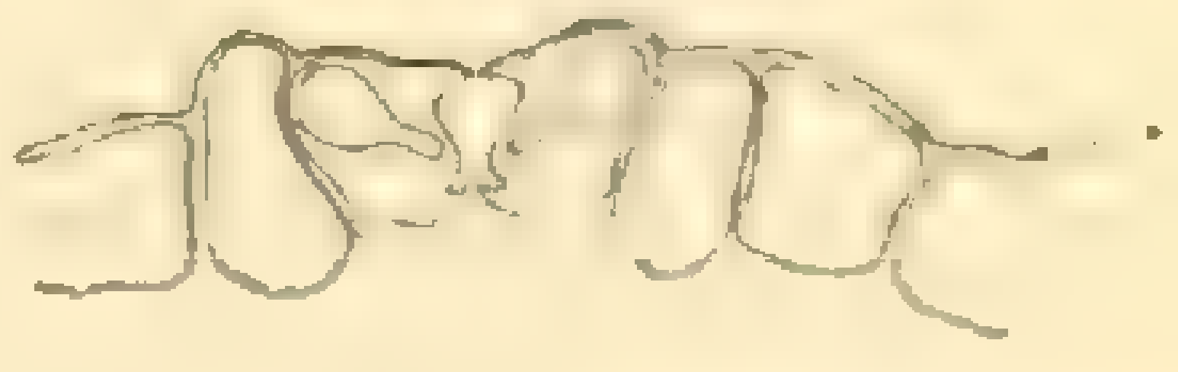


FIG. 7. Stoma from stem of *Baccharis genistelloides.*

THE STEM

In the plants examined, the stem varies in thickness from 1 to 4 mm. In the younger portions, to about 12 cm. from the tip, the supporting tissue consists largely of sclerenchyma, the wood proper being confined to a very narrow ring about 25 μ in diameter. The masses of bast-fibers are found at intervals around the stem, but the six largest masses are opposite the three wings and half way between them respectively (*f. 8*). These bast-fibers are strongly lignified, so that they give a much more pronounced reaction with phloroglucin than the young wood-ring itself. The lignification of the bast-fibers begins very near the growing tip; signs of it can be found at the distance of 1.5 cm. therefrom. This early acquisition of lignin would seem to indicate a very slow rate of growth — a point which will be recurred to presently.

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* Lloyd, F. E. Anatomy of *Chrysoma paucifiosculosa.* Bull. Torrey Club, **28**: 445. Au 1901.

† Bot. Zeit. **50**: 570. 1892.

The bast-bundles lie so close to the circle of wood — a feature according to Solereder characteristic of the Compositae — that no cambium was distinguishable as such in any portion of the stem of the growing plants. There are a number of thin-walled irregular cells between wood and bast, most of which are sieve-tubes; but some must be of a meristematic nature, because the wood-cylinder gradually increases in diameter so as to be about 60 mm. at a distance of 15 cm. from the tip, 125 mm. at 19 cm., and 166 mm. at the base of the plant examined.

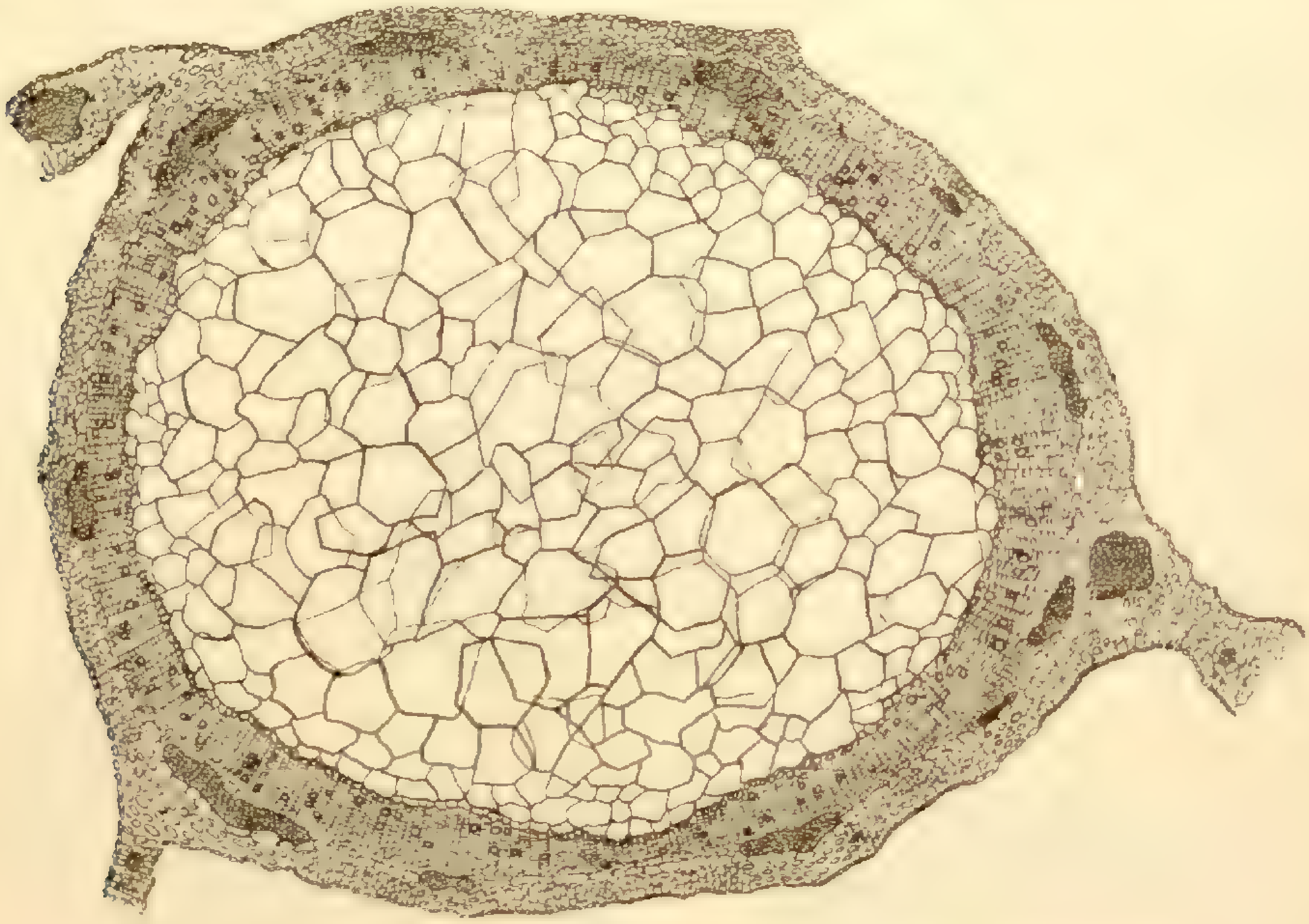

FIG. 8. Cross-section of stem of *Baccharis genistelloides*.

In an older stem taken from a herbarium specimen there were present three definite wood-rings and a very clearly established cambium layer. The wood on maceration was found to contain spiral, pitted and annular vessels. Wood parenchyma is abundant, but the medullary rays are obliterated. Around the primary bast-masses when they occur, otherwise external to the sieve tissue, an endoderm of one layer of rather large clear cells extends. Outside of this lies the cortex, of three or more rows of chlorophyl-bearing cells. Outside of the bast-bundles, however, these cells lose their chlorophyl and become collenchymatic. The angles of the older stems from which the wings have been lost become heavily suberized.

APOGEOTROPISM

The stems of *Baccharis genistelloides* are markedly apogeotropic. A number of the branches of plants which have been grown in a moist greenhouse have fallen down from their own weight. In all cases, however, the tips have turned perpendicularly upwards, and the plants present a very striking appearance in consequence. They are markedly different from the diageotropic shoots of *B. halimifolia*, which is growing in the same place. That this falling down of the branch is also characteristic of the plant in its natural environment is seen from herbarium specimens. There are often as many as six upright branches from one prostrate one.

THE WING

The wings are the conspicuous portion of the plant; they vary in width from a few millimeters at the youngest portions to 2 cm. at the older. The length depends upon their relation to the internodes. As shown above (*f. 1*) some wings go through only one, others through two internodes, the longer ones being from 10–18 cm., the shorter from 3–8 cm. A transverse section (*f. 9*) shows a very compact structure. There is no definite palisade or spongy tissue. Several rows of chlorophyl-bearing cells packed more or less closely extend inward from both surfaces. The air spaces, which are comparatively few, are chiefly situated in the middle of the wing. The stomata are approximately equal in number on both sides of the wing, averaging 70–80 to the square millimeter.

The wings are notably rigid; this is due to the occurrence of strands of mechanical tissue which are developed in connection with the vascular bundles. The conducting tissue plays but an unimportant rôle in the support of the wing. There is a particularly large stereome mass on the extreme edge, which is readily removable as a thick thread.

In order to determine the morphology of the wing, serial sections of the growing point were prepared. From these it appeared that the wings are directly continuous with the margins of the scales. On comparison with shoots bearing true leaves this view was substantiated. In the terms of many of the text-books, then, these wings would stand as "decurrent leaves"—as elaborations of the leaf-base, named by Vines the "hypopodium." Their peculiar phyllotactic arrangement would thus obviously be explained. The question was raised however as to whether these facts alone, *i. e.*, the connection with the leaf-base and their phyllotactic relation, would be sufficient to establish the homology with leaf-structures. The point was decided in the negative for the following reasons:

1. Their main axes, even at the growing point, are parallel to the stem, instead of at a greater or less angle as in other developed leaf-bases, *i. e.*, stipules.

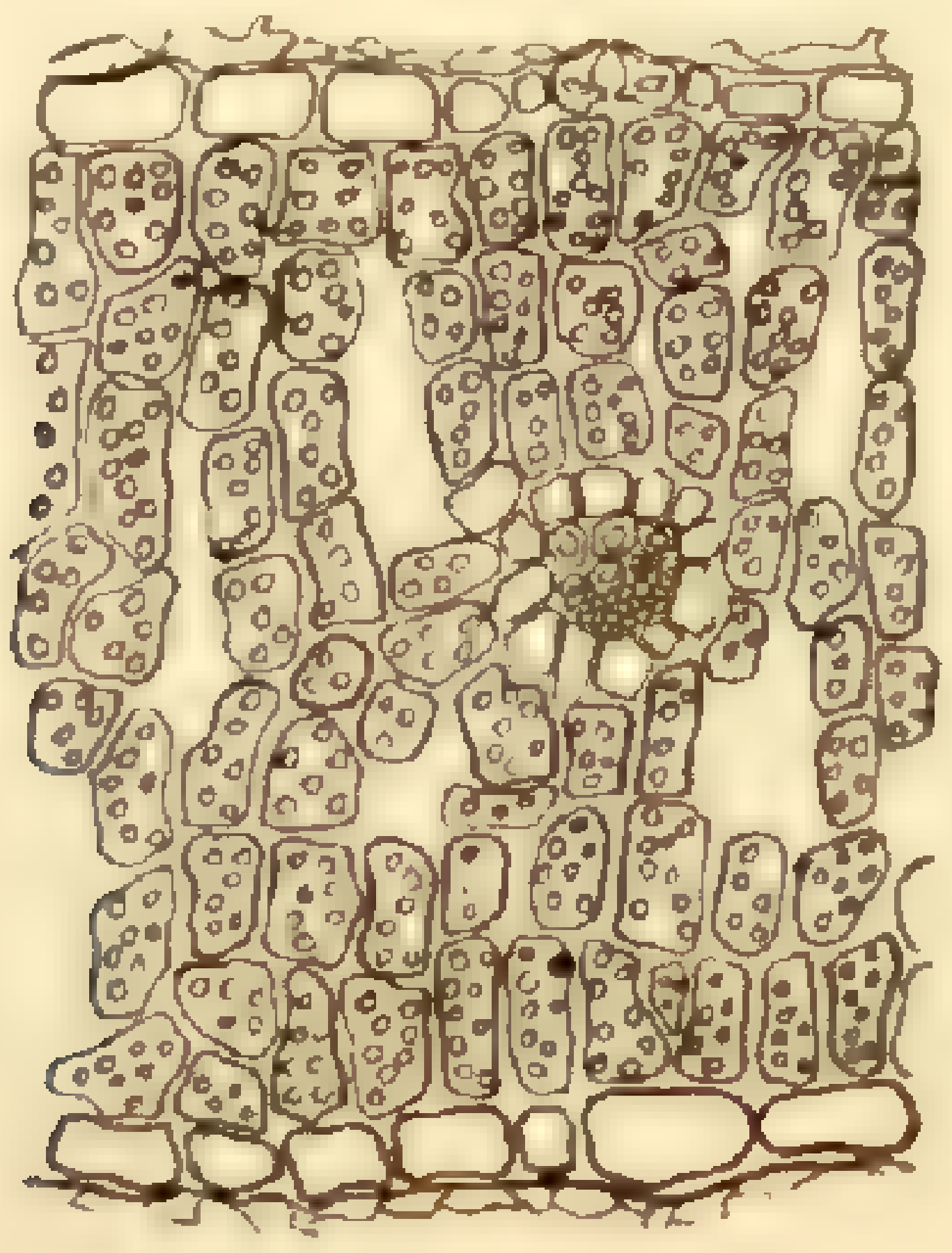

FIG. 9. Cross-section of wing of *Baccharis genistelloides.*

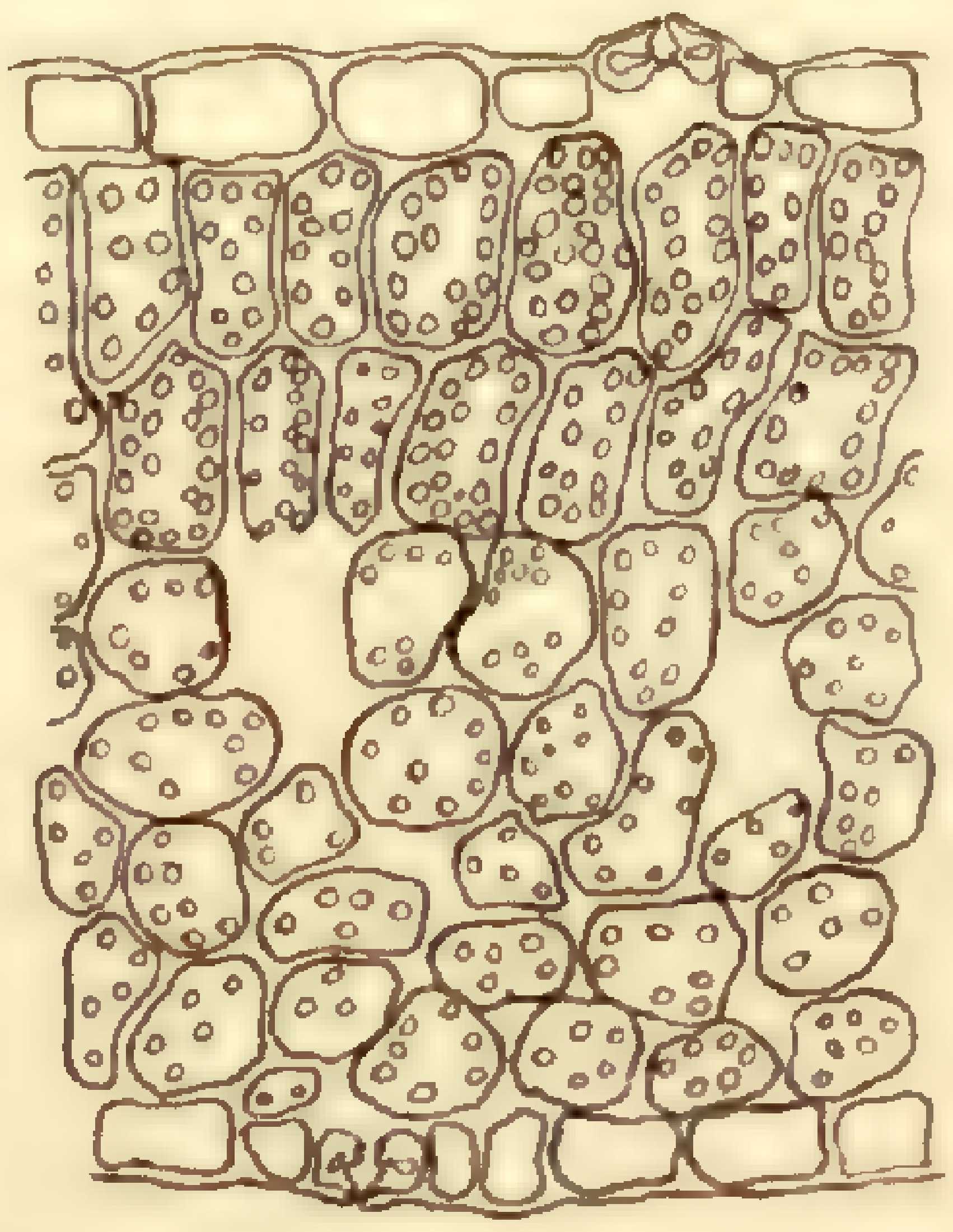

FIG. 10. Cross-section of leaf of *Baccharis genistelloides.*

2. In many plants, *Lathyrus latifolia*, *L. sylvestris* and *L. grandiflorus* among others, both stipules and wings occur. In such cases the wings, although just as obviously continuous with the wings of the petiole, evidently could not be hypopodia.

3. Other organs have been found that follow the leaf arrangement, but may not therefore be supposed to be leaf-structures — for example the thorns in some species of *Rubus* and *Smilax*, the ridges in the stems of *Urtica gracilis*, *Mentha crispa* and *Leptandra Virginica.*

For these reasons the wings are, it seems to me, rather to be regarded as lateral-vertical expansions of the stem than as "decurrent leaf-margins."

PHOTOTROPISM

To determine the action of the plant towards light a growing shoot was fastened in a dark chamber illuminated from one side only. After fourteen days there was found to be a decided phototropic reaction. The stem had turned towards the light, the bending region extending to about 3 cm. from the tip. The two wings nearest the aperture had turned at right angles to each other and in the direction of the rays, the third wing had moved to a position just behind and parallel to one of the others. In this way only its very edge was illuminated. Although at first it seemed as if the wings must have played a positive part in the movement towards the light, probably a purely mechanical explanation is to be assigned for their position. By experiment it was found that these would be the positions assumed by any rigid objects — such as strips of cardboard — fastened to a bending axis, so that probably only the stem was directly concerned in the reaction.

THE LEAF

The leaves themselves vary in size. The largest found measured 2.2 × 1.3 cm., the smallest 5 × 3 mm. (*f. 3*). They appear, as above pointed out, at the basal portion, but also occasionally on new shoots, developing from buds on these regions. A transverse section of the leaf (*f. 10*) shows that here also we have a fairly compact mesophyl structure. The intercellular spaces are, as in the wings, comparatively small. In the leaf, however, sharply distinguishing it from the wings in structure, we find a noticeable dorsi-ventral differentiation; for not only has the leaf a definite palisade parenchyma of two layers of cells, but a difference is also to be observed in the number of stomata present on the two surfaces. There are 106 stomata to the square millimeter on the lower surface to 50 on the upper. It is to be noted as significant that the whole number of stomata per square millimeter would average almost exactly the same in the case of the wing and the leaf.

REVERSION TO THE JUVENILE LEAF-FORM

Several experiments were started with a view to inducing the re-formation on adult shoots of the juvenile leaf-form. Some of the growing shoots were kept in a moist chamber, others in a dry and still others in a dark chamber for several weeks, but no results were obtained. This may have been due to one or more of several causes. First, of course, these particular agents may not induce leaf-formation in this plant; or again the failure may have been due to the fact that growing shoots (and therefore shoots very far from the usual basal region of leaf-production) were used; or finally, it may have been due to the fact that all the shoots which were experimented with formed flower-buds on being released, as it is believed that when a shoot has once laid down the primordium of a flower it is thereafter unchangeable.

To avoid the repetition of these conditions it was determined to defer the experiments until such a time as separate plants would be available for the different experiments. For this purpose, but also more particularly to determine the effect upon the leaf-reversion, a large number of cuttings were made, consisting, of course, of the youngest shoots, *i. e.*, those farthest from the juvenile character. The cuttings were difficult to root; less than half of those planted at three different times succeeded. At present, however, there are about 15 more or less healthy young plants.

On three of the cuttings which were planted earliest, reversion shoots of a remarkable character developed. The first one to be affected produced from buds two branches, on each of which appeared three reversion leaves, and on which the wings were reduced almost to a minimum. Also (and this seems extraordinary) the main shoot produced near its apex several smaller leaves. This is the plant represented in *f. 11.*

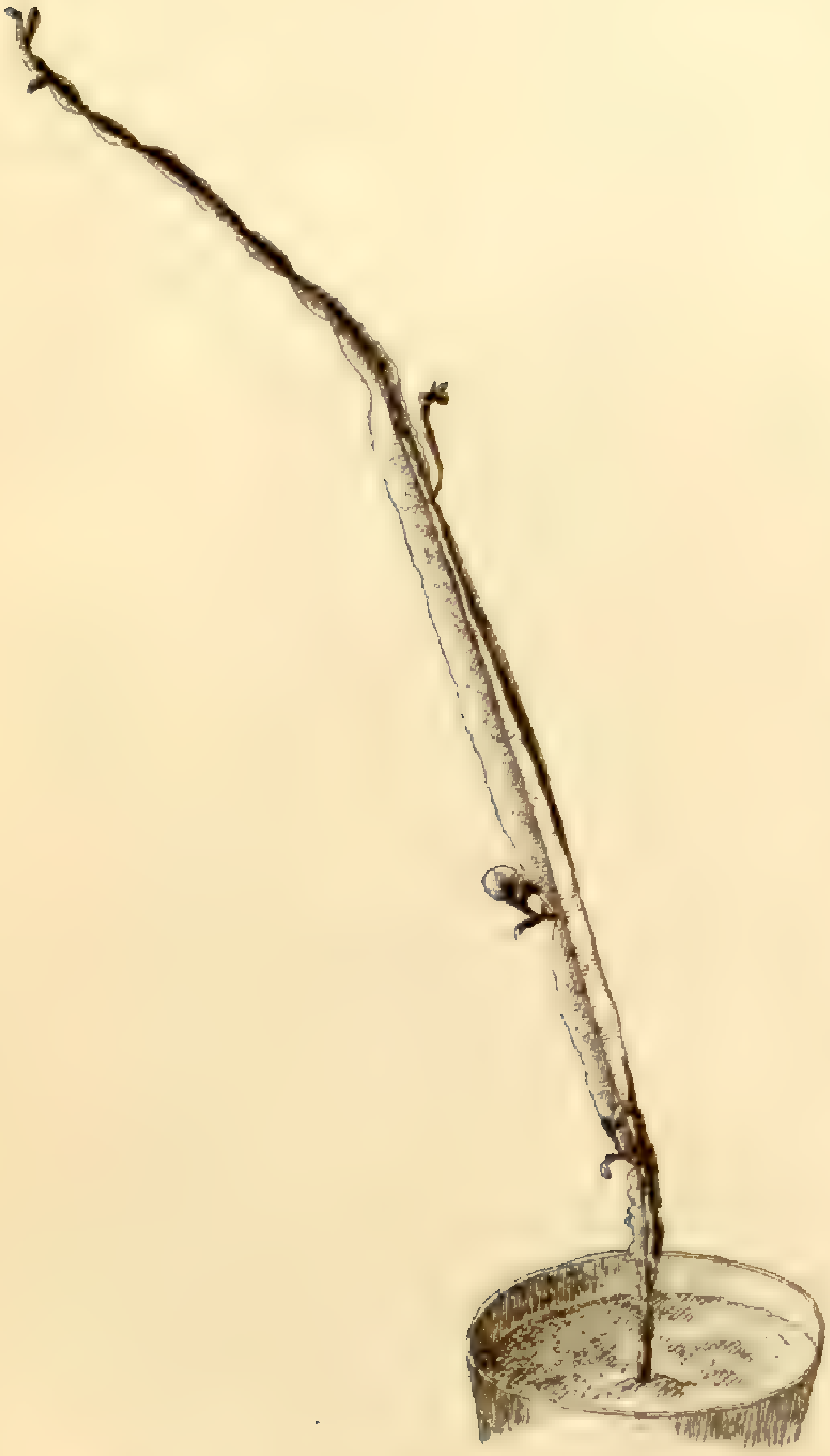

FIG. 11. Cutting of *Baccharis genistelloides*, showing production of juvenile leaves.

On the second plant a similar set of phenomena was observable. Three shoots bearing some of the largest leaves that have been found and the greatly reduced wings appeared, and at the same time the tip of the shoot continued to produce leaves as it grew.

On the third the main shoot withered; and one of the buds produced a branch on which the wings are apparently normal, but on which three small leaves have been found. Four other plants produced leaves on branches that retained their wings.

The apogeotropic habit of the secondary branches made another experiment possible. A plant on which the main branch had fallen from its own weight and on which there were a number of such upright shoots was layered — that is, had its main stem covered with earth. After allowing the branches to rest in this condition for some time, the connection of the vertical shoots with one another and with the main stem was severed. However, although all the shoots flourished and grew into separate plants, none produced the leaves.

To sum up briefly the most important points brought out in this investigation:

1. *Baccharis genistelloides* is a plant remarkably well adapted by the loss of leaves, by the position of the wings, and by the coverings of the cutin, wax and hairs, to withstand a high degree of both dryness and insolation.

2. The glandular hairs differ from the hairs previously described in the Compositae in the possession of chlorophyl, and the whip-hairs in being biserial.

3. The early acquisition of lignin in the bast of the stem, and of mechanical tissue in the wings, gives to the plant its characteristic rigidity, and at the same time necessitates a short period of elongation.

4. The leaves found in any given portion of the stem on the older parts of the plant resemble closely the leaves of other species of *Baccharis*.

5. The leaf differs from the wing in structure in showing marked dorsiventrality, which is absent in the latter.

6. While the wings are directly continuous with the margins of the scales and of the leaves when present, and while they follow the phyllotaxy, they are to be considered morphologically as lateral-vertical expansions of the stem and not as "decurrent leaves."

7. The shoots have been shown to be markedly apogeotropic and positively phototropic.

8. Cuttings of growing shoots were made, a number of which after rooting produced branches which bore reversionary leaves and greatly reduced wings; the apices of the old shoots also produced the leaves in two cases.

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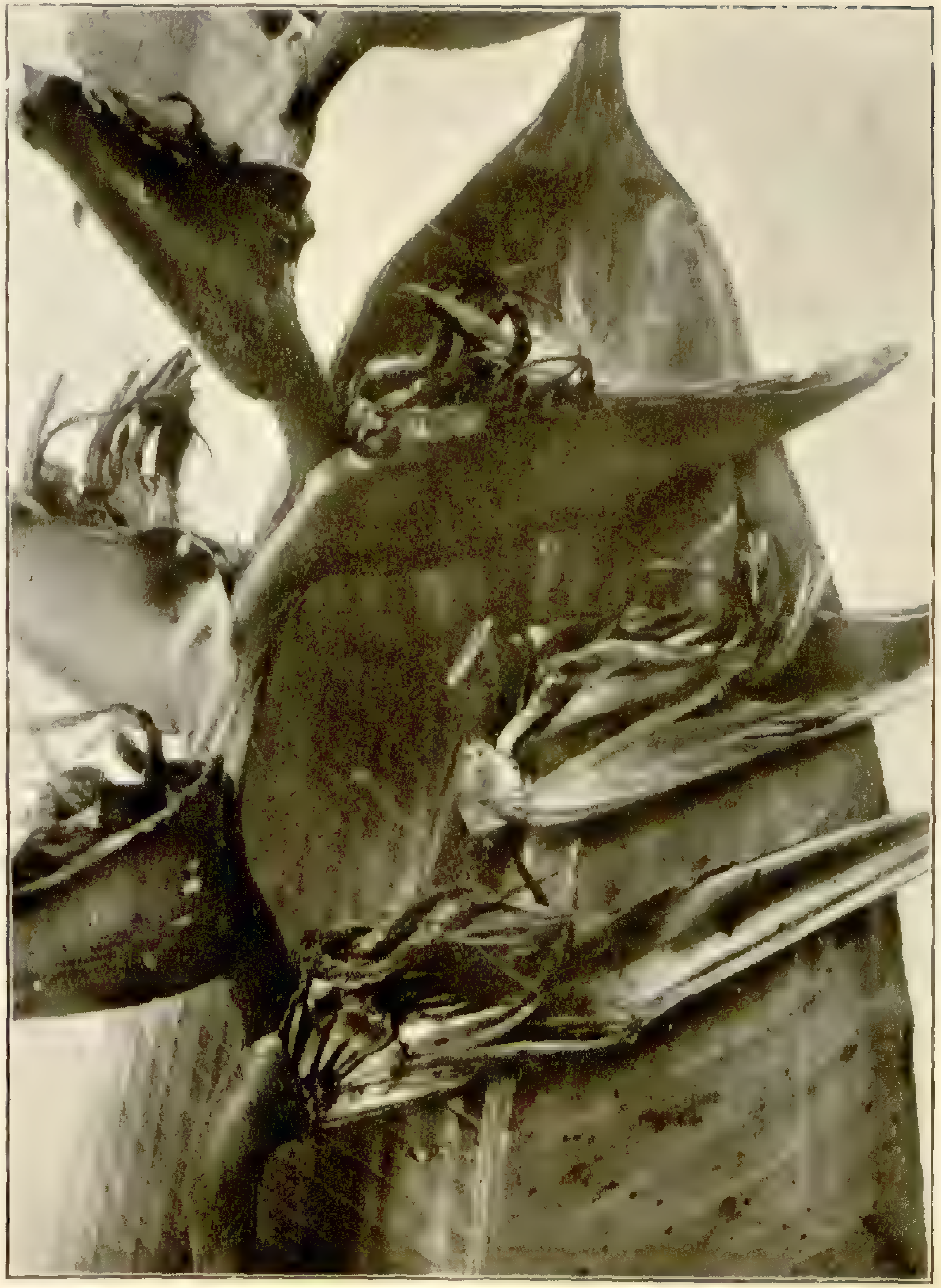

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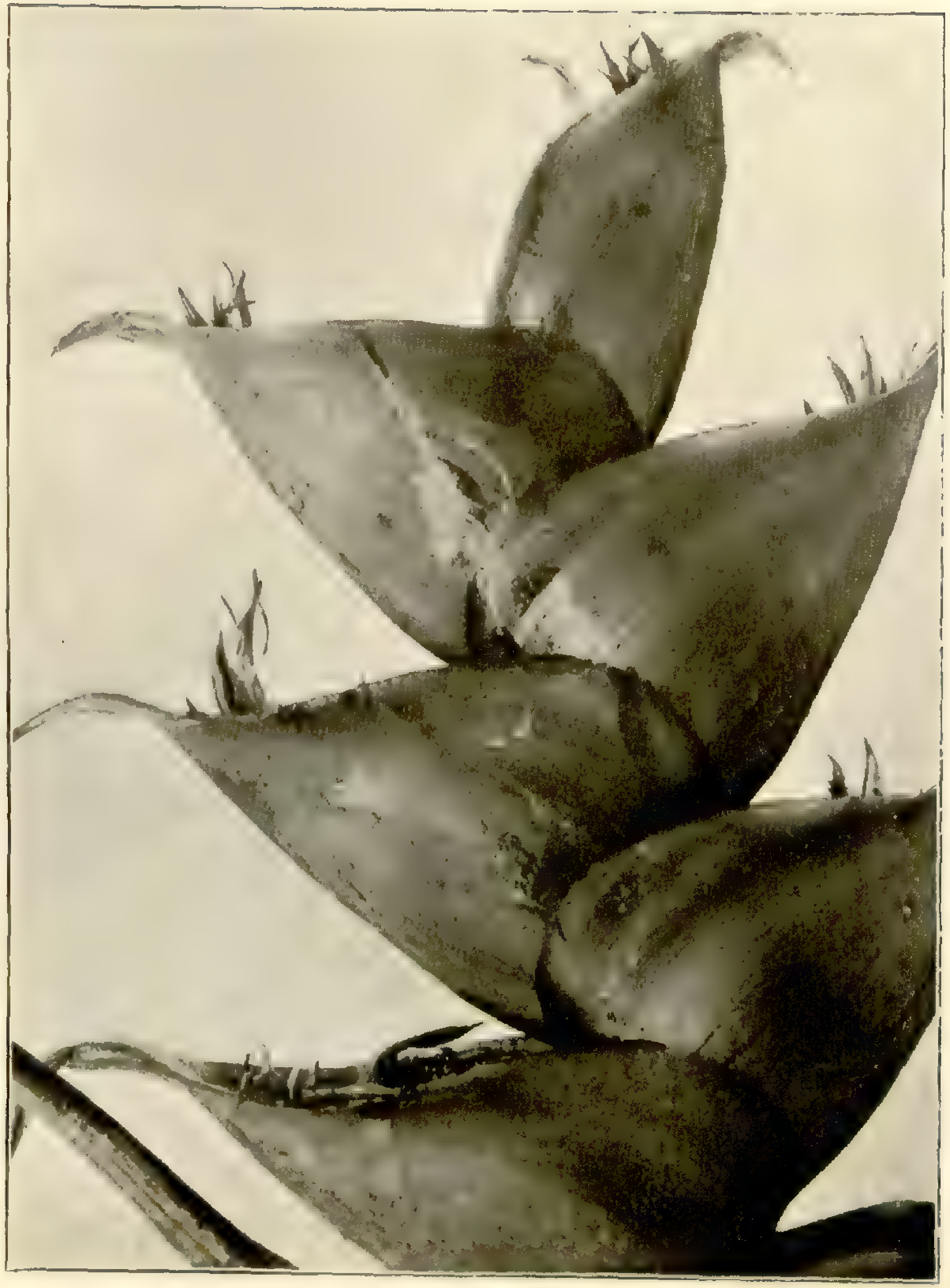

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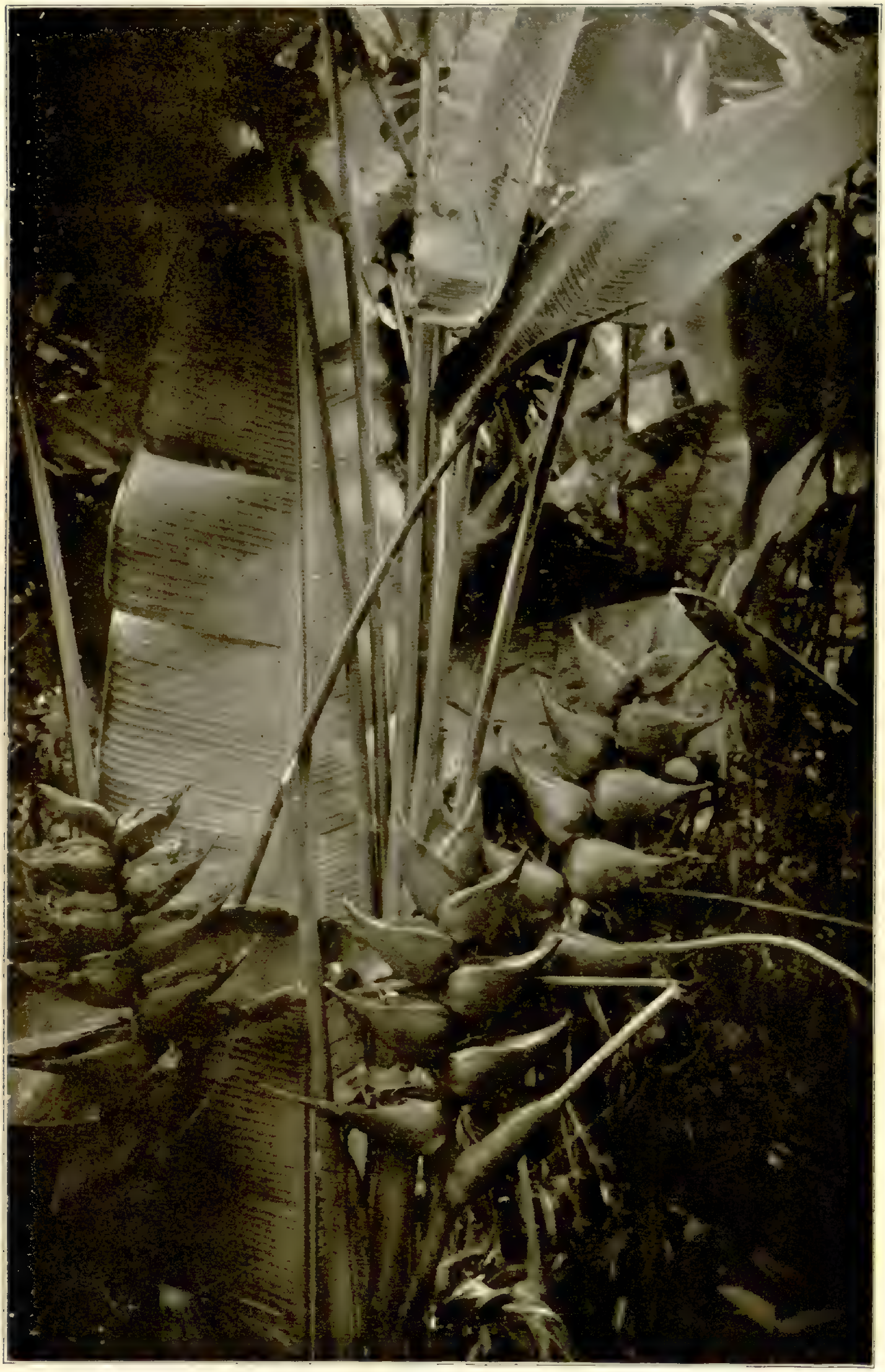

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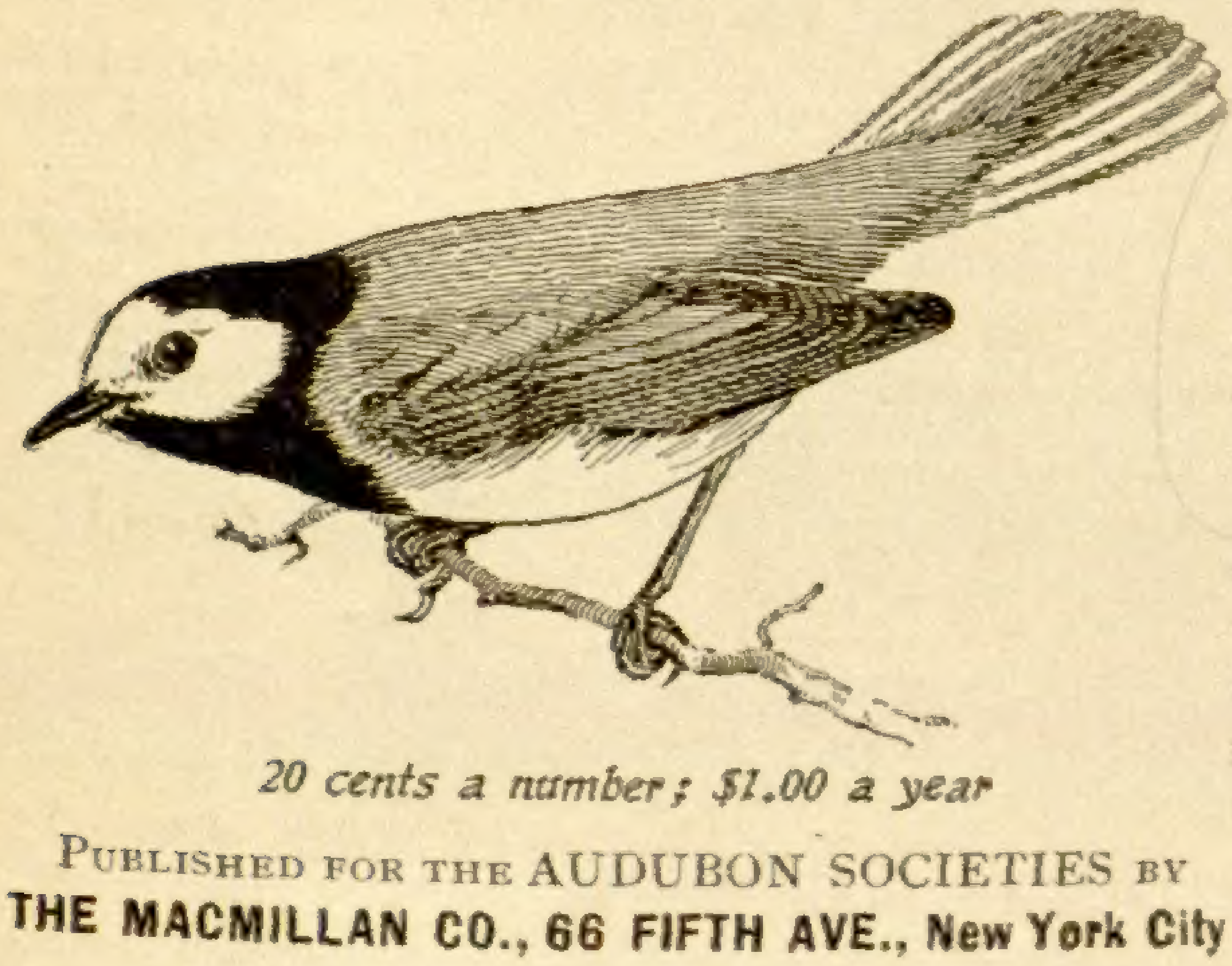

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